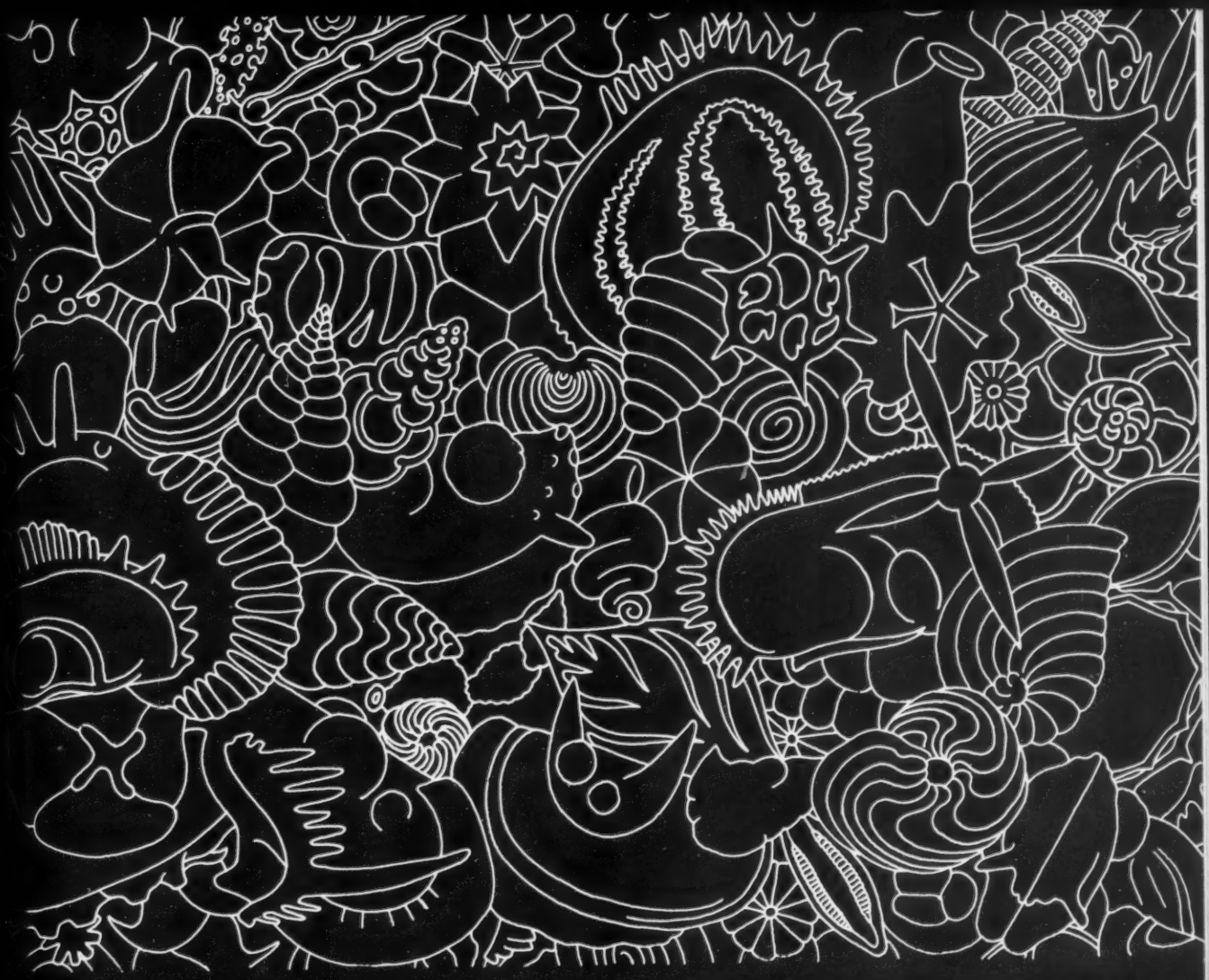

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ABSTRACT: *The variability in shape of the embryonic chambers of* Lepidocyclina (Pliolepidina) pustulosa *H. Douvillé from the American upper Eocene and* L. (Eulepidina) radiata (*Martin*) *from the Indo-Pacific Miocene is discussed and illustrated. Each of these species contains specimens which have a single set of embryonic chambers, others which have two sets of these chambers and still others possess multiple embryonic chambers. The probable cause of this development in the two species is given. Synonyms of the species are discussed. A tentative revision of the subgenera of* Lepidocyclina *is given.*

Variability in embryonic chambers of Lepidocyclina

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INTRODUCTION

In the genus *Lepidocyclina* two subgeneric names have been proposed for specimens with embryonic apparati which are composed of a large central chamber which is partially or completely surrounded by smaller chambers. These specimens usually occur with others which have the same kind of equatorial and lateral chambers, but which have a single set of bilocular embryonic chambers. Therefore, the separation of these specimens into distinct subgenera has been based largely on the kind of embryonic chambers present. However, there have been many suggestions that such a separation is not correct.

This study reviews and enlarges the opinion expressed by Vaughan and Cole (1941, p. 64) that the American upper Eocene species known as *Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé has an extremely variable embryonic apparatus. In addition it will be demonstrated that numerous species of the Indo-Pacific Miocene which have been assigned to various subgenera including *Multilepidina* (= *Cyclolepidina*) represent only one species, and, therefore must be combined under one subgeneric and specific name.

ACKNOWLEDGEMENTS

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LOCALITIES

Panama

1) U.S.G.S. station 6523, 2 miles north of David; D. F. MacDonald, collector.

2) West shore of Madden Lake at abandoned Salamanca Gaging Station, fairly soft limestone; T. F. Thompson and W. P. Woodring, collectors (Cole, 1952, p. 4, locality 132).

Trinidad

3) Kugler station K2854, Soldado Rock, San Fernando (Vaughan and Cole, 1941, p. 14).

4) Vista Bella, San Fernando; H. G. Kugler, collector, May 1932.

Grenada, Windward Islands

5) Loose block from stream side near Clozier Bridge at 1135 feet above sea level on the Belvidere Road, Gouyave side; P. Martin-Kaye, collector, locality 4961.

United States

6) Near Duncan Church, 7 miles southwest of Chipley, Washington County, Florida; G. M. Ponton, collector (Cole, 1934, p. 21).

7) Weston Library well no. 2, Sun Oil Company, Hancock County, Mississippi, at a depth of 4510–4540 feet; permission to use this material granted by R. D. Wood of the Humble Oil and Refining Company in letter dated 16 January 1956.

Borneo

8) Kahajan (report no. 105-Kah. I, no. 417, 421.5–422.5 m.); specimen is a gift from I. M. van der Vlerk.

9) Soengei-Jama-ah, British North Borneo (report no. 102, borehole J1059); specimen is a gift from I. M. van der Vlerk.

Viti Levu, Fiji

10) Abandoned quarry on the south side of Walu Bay, near entrance; sample from the middle of the limestone near the west end of quarry face, H. S. Ladd, collector (Ladd, 1934, p. 84, locality 328).

11) Same as locality 10, but from the upper part of the limestone mass (Ladd, 1934, p. 84, locality 329).

12) Upper (north) entrance to cave at Kalambu; elevation about 120 feet (Ladd, 1934, p. 84, locality 316).

Lau, Fiji

13) Basal foraminiferal limestone, near western end of western lake, Oneata; altitude about 15 feet (Ladd and Hoffmeister, 1945, p. 189, locality L466).

MULTIPLE EMBRYONIC APPARATI

In certain populations of larger foraminifera some specimens have two or more sets of embryonic chambers. Beyond these multiple embryonic chambers the equatorial and lateral chambers develop similar to those of individuals which have only one set of embryonic chambers. In the description of *Discocyclina cloptoni* (= *Pseudophragmina* (*Proporocyclina*) *perkinsi* (Vaughan)) Vaughan (1929, p. 14) stated: "There may be two, three or four such pairs of chambers, as is shown in the illustration" (*his* pl. 5, figs. 2–5). Later, Cole and Gravell (1952, p. 721, pl. 95, fig. 6) illustrated a Cuban specimen of this species with multiple embryonic chambers.

Specimens identified as *Pseudophragmina* (*Proporocyclina*) *zaragosensis* (Vaughan) from a drill hole in Mississippi with multiple embryonic chambers are illustrated as figures 4–5, plate 4. The type of this species was described from Mexico and other specimens referable to this species were found in Florida. The Mexican and Floridian specimens so far examined have a single set of embryonic chambers. However, the majority of the specimens from Mississippi have multiple sets of embryonic chambers although a few specimens have a single set of embryonic chambers.

In the genus *Lepidocyclina*, specimens with multiple sets of embryonic chambers have been reported from Peru (L. Rutten, 1928, pl. 1, figs. 13, 15) and from Curaçao (M. G. Rutten and Vermunt, 1932, pl. 2, fig. 9; pl. 3, figs. 3, 4). Glaessner (1945, p. 61) has stated: "Accidental coalescence of foraminiferal tests and twinning at early stages of growth leading to the formation of individuals with two or more initial chambers (White, 1936; Hayasaki, 1936) is an accident of growth and should not be confused with plastogamy which occurs toward the end of the life span of individuals." White (1936, p. 123) in discussing certain fusulinids with multiple embryonic chambers wrote: "They were discussed in order to prevent their appearing as new species or genera...."

MULTIPLE EMBRYONIC CHAMBERS

Although the phenomenon of multiple embryonic chambers in the larger foraminifera occurs with sufficient frequency so that it cannot be considered an abnormality, their occurrence does require explanation inasmuch as multiple embryonic chambers seemingly occur more consistently in the species *Lepidocyclina pustulosa* and *L. radiata* than in other known species of this genus. Moreover, other species of *Lepidocyclina* as well as species of other genera of larger foraminifera are usually associated with these two species of *Lepidocyclina*. These associated specimens, rarely, if ever, have multiple embryonic chambers, therefore it would seem that this phenomenon is not entirely ecologically controlled. In addition, individuals of the same species with a single set of embryonic chambers occur with those with multiple sets.

However, it has been observed that in a sample from one locality, individuals with a single set of embryonic chambers predominate, whereas in a sample from another locality individuals with multiple embryonic chambers are the most abundant. There may be ecological conditions which influence the production of multiple embryonic chambers provided the species has certain genetic tendencies, such as, the development of a thick-walled multiple fission cyst. If certain external stimuli are not available, the majority of the individuals reproduce in such a manner that the gamonts do not associate in groups. However, if suitable ecological conditions are present, the megalospheric gamonts associate rather than separate.

Although little is known concerning the life histories of the larger foraminifera, Myers (1935, p. 360) in his detailed observations of the life history of *Patellina corrugata* Williamson may have given a clue to the production of multiple embryonic chambers in certain of the larger foraminifera. He observed in the development of the megalospheric test that "Protoplasmic differentiation accompanied by the secretion of a test around each nucleus results in twelve megalospheric young which now simultaneously part. Before the individuals of the new sexual generation break free from the multiple fission cyst each is provided with a calcified test consisting of a proloculum and a spiral chamber of about one and three-fourths whorls."

If it may be assumed that the larger foraminifera produce some kind of a multiple fission cyst for "protection during the defenseless period of asexual reproduction

by multiple fission" (Myers, 1935, p. 360) as *Patellina corrugata* does, it follows that under certain conditions the megalospheric young may not "simultaneously part." Therefore, they will produce a multichambered embryonic apparatus. It is postulated that under certain ecologic conditions *Lepidocyclina pustulosa* and *L. radiata* form a multiple fission cyst with unusually thick walls in which disassociation of the gamonts is not possible at the proper instant, therefore the gamonts do not separate. However, if the wall of the multiple fission cyst is thin, or conditions are such that it ruptures easily the gamonts escape at the proper time, thus initiating individuals with a single set of embryonic chambers.

THE SUBGENUS PLIOLEPIDINA

The subgeneric name *Pliolepidina* was proposed by H. Douvillé in 1915 (p. 727, fig. 34) for specimens from the upper Eocene of Trinidad which had an embryonic apparatus consisting of a large central chamber with bordering small chambers. However, he did not propose a specific name for these specimens until 1917 (p. 844, text-figs. 1–6) at which time he introduced the specific name *tobleri*. This species became the type of the subgenus *Pliolepidina* as it was the only specific name proposed.

Later, Vaughan and Cole (1941, p. 64) recognized that specimens assigned to *Pliolepidina tobleri* H. Douvillé, 1917, were specifically the same as specimens which were named by H. Douvillé *Isolepidina pustulosa* (1917, p. 844). As the name *pustulosa* was the first name used by Douvillé, Vaughan and Cole considered that this name should be used for the combined species. Douvillé had placed *pustulosa* in the subgenus *Isolepidina* which is a synonym of *Lepidocyclina* (*Lepidocyclina*) (*Isolepidina* Douvillé, 1915 = *Lepidocyclina* Gümbel, 1870, as both are based on *Lepidocyclina mantelli* (Morton)). Therefore, Vaughan and Cole emended the definition of *Pliolepidina* to include specimens with a single set (fig. 3, pl. 2) of embryonic chambers as well as those with one large chamber with smaller peripheral chambers. Thus, *L.* (*Pliolepidina*) *pustulosa* became the type species of this subgenus according to Article 27 of the Rules of Zoological Nomenclature which states: "The Law of Priority obtains and consequently the oldest name is retained: *d*) When an animal represents a regular succession of dissimilar generations which have been considered as belonging to different species or even to different genera."

Although Vaughan and Cole recognized that *L. tobleri* was a synonym of *L. pustulosa*, they were impressed with the character of the embryonic chambers which they considered to be abnormal (teratologic). Therefore, they listed specimens previously called *L. tobleri* under the designation "*Lepidocyclina* (*Pliolepidina*) *pustulosa* forma *tobleri* H. Douvillé, forma teratologica." However, their intent should be clear as they (1941, p. 67) wrote: "The species should bear the name *L. pustulosa*, with *L. tobleri* recognized as a teratologic variant." If this intent is granted, only one species is possible, namely, *L. pustulosa*, with *L. tobleri* as a synonym.

Recently, Grimsdale and van der Vlerk (1958, p. 4) reviewed the status of the subgeneric name *Pliolepidina*. They wrote (p. 5) "... *Lepidocyclina pustulosa* was not included under the name *Pliolepidina* at the time of its publication and so can never become the type species." However, if *tobleri* is a synonym of *pustulosa*, the name *pustulosa* can be used according to Article 27, *d*, of the Rules of Zoological Nomenclature as the subgenus *Pliolepidina* is monotypic. *L. pustulosa* and *L. tobleri* represent only one species which must be the type of *Pliolepidina*. The validity of the name *Pliolepidina* with *L. tobleri* as the type species has not been questioned. The substitution of the specific name *L. pustulosa* is the debatable point. Therefore, the validity of this substitution depends upon the biologic proof that Douvillé described a single species under two specific names. Although at one time in the study of these specimens the writer (Cole, 1952, p. 17), following Woodring (1927), considered that the specimens with multiple embryonic chambers might be a subspecies of *L. pustulosa*, the evidence for a single species is so convincing from the data available now that this concept must be abandoned.

EMBRYONIC CHAMBERS OF LEPIDOCYCLINA PUSTULOSA

Plate 2, figures 1–10; plate 3, figures 1, 2, 5, 6, 9, 10; plate 4, figures 7, 9

Vaughan and Cole (1941, p. 67) wrote: "Specimens of *L. trinitatis* with double embryonic chambers occur in Trinidad and Venezuela, and such a specimen from Curaçao has been given the specific name *vanslobbeni* by M. G. Rutten and Vermunt (1932)." Rutten and Vermunt's specimens are identical with specimens of *L. pustulosa* (= *L. trinitatis*) except they have two sets of perfectly formed embryonic chambers.

Thus, there is undoubted proof that the initial stage of certain individuals of *L. pustulosa* may be composed of two sets of embryonic chambers beyond which the individual develops as if it contained only a single set of embryonic chambers. Moreover, it can be shown in *Pseudophragmina* (fig. 4, pl. 4) that the embryonic chambers may be made of more than two sets of embryonic chambers, yet the individual may develop normally beyond this stage. The type illustration of "*tobleri*" (Douvillé, 1917, p. 844) is similar to one illustrated as figure 1, plate 3. Whereas the embryonic chambers of specimens with a single set of embryonic chambers (figs. 1, 3, 4, 6, 9, pl. 2; fig. 9, pl. 3) all conform within predictable limits, those of "*tobleri*" are extremely variable (compare figs. 5, 7, pl. 2 with figs. 1, 2, pl. 3).

If figure 5 (by transmitted light), plate 2 and figure 9 (the same specimen by reflected light), plate 4 are ex-

amined, it will be observed that there is a set of bilocular embryonic chambers (on figure 5, plate 2 to the upper right of the main embryonic mass and on figure 9, plate 4 to the right center of the main embryonic mass) which conform to those found in specimens with a single set of embryonic chambers. A similar set of bilocular embryonic chambers is found at the bottom of the embryonic mass in figure 2, plate 2. Unfortunately, a part of the wall adjacent to the large central chamber was destroyed in mounting this specimen. Figure 7, plate 2 illustrates an individual with two embryonic masses. The other specimens illustrated (figs. 8, 10, pl. 2; figs. 5, 6, 10, pl. 3; fig. 7, pl. 4) have only one embryonic mass, but each presents a different pattern.

These irregularities, in addition to the occurrence of "normal" bilocular embryonic chambers in association with the "abnormal" embryonic masses, suggest that in certain individuals one gamont is responsible for the construction of the test ("*L. pustulosa* type"), in others two gamonts produce the individual ("*L. vanslobbeni* type"), and, finally, several gamonts may generate the test ("*L. tobleri* type"). There is complete gradation in the embryonic apparati of the species *L. pustulosa*. Except for the development in the embryonic chambers, the other structures are identical. Figure 3, plate 3, represents the equatorial chambers of a specimen with a single set of embryonic chambers, whereas figure 4, plate 3 shows equatorial chambers of a specimen with "*tobleri*" type embryonic chambers. These equatorial chambers have exactly the same shapes and pattern.

LEPIDOCYCLINA (PLIOLEPIDINA) PUSTULOSA

The synonyms of *Lepidocyclina pustulosa* given by Vaughan and Cole (1941, p. 65) and Cole (1952, p. 16) and those of *L. pustulosa* forma *tobleri* given by Vaughan and Cole (1941, p. 66) and Cole (1952, p. 17) are accepted, but the two lists should be combined as only one species is represented. Grimsdale (1959, p. 30) objected to the inclusion by Cole (1952, p. 16) of *Lepidocyclina subglobosa* Nuttall (1928, p. 104) in the synonymy of *L. pustulosa*. He wrote in part "... on the contrary I had considerable trouble in separating *L. subglobosa* from *L. yurnagunensis*." Therefore, an illustration (fig. 8, pl. 3) of the embryonic and equatorial chambers of *L. yurnagunensis* is introduced for comparison with these same structures in *L. pustulosa*. Nuttall's illustration (1928, fig. 6, pl. 8) of *L. subglobosa* should be compared with figure 8, plate 25 (Vaughan and Cole, 1941) and with figure 3, plate 2, of *L. pustulosa*. All of these sections are identical.

Lepidocyclina yurnagunensis has equatorial chambers which are normally diamond shape, whereas *L. pustulosa* has short spatulate chambers. The radial diameter of the equatorial chambers of *L. pustulosa* is usually greater than the tangential diameter, whereas the reverse is the case in *L. yurnagunensis*. *L. yurnagunensis* has been assigned to the subgenus *Lepidocyclina* sensu stricto. This assignment is incorrect, and it should be reassigned to the subgenus *Eulepidina* (see following discussion).

THE SUBGENUS MULTILEPIDINA

Certain specimens from the Miocene of the Indo-Pacific region possess irregular embryonic chambers, some of which are of the kind exhibited by certain specimens of *Lepidocyclina* (*Pliolepidina*) *pustulosa* of the American upper Eocene. One of the first of these to be described was *L. luxurians* Tobler (1925, p. 269) (fig. 11, pl. 4) from the Miocene of Sumatra. Tobler assigned this species questionably to the subgenus *Pliolepidina*.

Later, Hanzawa (1932, p. 447) described a species, *L. irregularis*, from the Miocene of Formosa which he designated as the type of a new subgenus *Multilepidina*. Whipple (1934, p. 143) found specimens in the Miocene of Vitilevu, Fiji, which he named *L. suvaensis* and which became the type of his subgenus *Cyclolepidina*. Cole in 1935 studied specimens from the Lau Islands, Fiji, and concluded that *Cyclolepidina* was a synonym of *Multilepidina*. This study was not published, however, until 1945. In the meantime, Caudri (1939, p. 232) independently demonstrated that *L. suvaensis* was a synonym of *L. luxurians*. She placed *L. irregularis* questionably in the synonymy of *L. luxurians*. Moreover, she suggested that *L.* (*Nephrolepidina*) *borneensis* Provale (fig. 10, pl. 4) probably should be combined with *L. luxurians* (fig. 11, pl. 4). Cole (1945, p. 292) had described a species under the name *L.* (*Eulepidina*) *oneataensis* from the Miocene of Lau, Fiji. The equatorial sections (Cole, 1945, pl. 26, figs. A–D) showed that the embryonic chambers of this species were variable, therefore, additional sections were prepared for this study (figs. 1–3, 6–8, 10, pl. 1; fig. 7, pl. 3).

LEPIDOCYCLINA (EULEPIDINA) RADIATA (MARTIN)

It has been suggested in the preceding section that several specific names have been given to specimens in the Miocene of the Indo-Pacific region which should be placed only in one species. Therefore, before the embryonic chambers of this species are discussed, it is appropriate to review some of these specific names.

Caudri (1939, p. 232) demonstrated that *Lepidocyclina suvaensis* Whipple, 1934, was a synonym of *L. luxurians* Tobler, 1928. She (p. 228) placed *L. transiens* Umbgrove, 1929, in the synonymy of *L. borneensis* Provale, 1909. Moreover, she suggested that *L. luxurians* probably was a synonym of *L. borneensis*.

Whipple (1934, p. 148) illustrated specimens from the Miocene of Vitilevu, Fiji, which he assigned to *Lepidocyclina* (*Eulepidina*) *radiata*. These specimens were associated with specimens of *Lepidocyclina* (*Cyclolepidina*) *suvaensis* at one station. Although the specimens assigned to *L.* (*E.*) *radiata* superficially appear to be distinct in external appearance from those which were named *L. suvaensis*, they are identical in internal structure except for the embryonic chambers.

Lepidocyclina radiata was described by Martin (1880, p. 163) from the Miocene of Java. Unfortunately, the

TABLE 1

COMPARISON OF THE EMBRYONIC CHAMBERS IN INDO-PACIFIC SPECIES OF *Lepidocyclina*

Species	Author	Citation	Compare with
L. borneensis	Provale	1909, pl. 3, fig. 18	*Fig. 10, pl. 1; fig. D, pl. 26[1]
L. borneensis	Provale	1909, pl. 3, fig. 17	*Fig. 8, pl. 1
L. borneensis	Cole	1960, pl. 4, fig. 10	*Fig. 2, pl. 1
L. transiens	Umbgrove	1929, fig. 5	*Fig. 3, pl. 1
L. radiata	Whipple	1934, pl. 19, fig. 5	*Fig. 6, pl. 1
L. radiata	Cole	1945, pl. 23, fig. E	*Fig. 6, pl. 1
L. gerthi	Caudri	1939, pl. 9, fig. 66	*Fig. C, pl. 26[1]
L. luxurians	Tobler	1925, pl. 8, fig. 1	*Fig. 1, pl. 1
L. suwaensis	Cole	1960, pl. 4, fig. 1	*Fig. 10, pl. 1
L. luxurians	Cole	1960, pl. 4, fig. 11	**Fig. 6, pl. 4
L. fijiensis	Cole	1945, pl. 22, fig. B	***Figs. 82–84, pl. 10[2]
L. irregularis	Hanzawa	Cushman, 1948, pl. 41, fig. 9	**Fig. 9, pl. 1
L. suwaensis	Cole	1960, pl. 4, fig. 1	*Fig. 10, pl. 1
L. borneensis	Provale	1909, pl. 3, fig. 18	**Fig. 1, pl. 20[3]

[1] Cole, 1945
[2] Caudri, 1939
[3] Whipple, 1934

*"*L. oneataensis*"
**"*L. suwaensis*"
***"*L. luxurians*"

species is illustrated only in external appearance. However, the specimens from Vitilevu, Fiji, illustrated by Whipple (1934, pl. 19, figs. 3, 6) are identical with the illustration given by Martin of *L. radiata*.

Cole (1945, p. 292) identified specimens from the Miocene of the Lau Islands, Fiji, with *Lepidocyclina* (*Eulepidina*) *radiata*. These specimens were associated with specimens which were assigned to a new species, *Lepidocyclina* (*Eulepidina*) *oneataensis* Cole (1945, p. 292). He (p. 293) identified other specimens with *L.* (*E.*) *transiens* Umbgrove because they lacked a marked rim although he admitted that internally they were similar to *Lepidocyclina* (*Eulepidina*) *oneataensis*. All the species so far mentioned have elongate hexagonal chambers (figs. 2, 3, pl. 4), the lateral chambers are arranged in regular tiers (figs. 4, 5, pl. 1; fig. 8, pl. 4), the chamber cavities are rectangular and the floors and roofs are thin. The embryonic chambers are variable and the external appearance, although normally radiate, is variable. Caudri (1939, p. 221) had described a new species, *Lepidocyclina gerthi*, from Ngampel which has the general external and internal appearance of certain specimens which were named *Lepidocyclina* (*Eulepidina*) *oneataensis* although she did not illustrate the vertical section.

Inasmuch as the specimens from Fiji seemingly were identified correctly with *Lepidocyclina radiata* and as the other specimens mentioned are without doubt the same as *L. radiata*, it follows that *L. radiata* has priority as the specific name to be used with the following as synonyms:

L. borneensis Provale, 1909

L. luxurians Tobler, 1928

L. transiens Umbgrove, 1929

L. irregularis Hanzawa, 1932

L. suwaensis Whipple, 1934

L. gerthi Caudri, 1939

L. fijiensis Cole 1945

L. oneataensis Cole, 1945

There may be other synonyms of this variable species, but the listing of these names will be sufficient for the time. Proof for the combination of these species will be given in the following section.

EMBRYONIC CHAMBERS OF LEPIDOCYCLINA RADIATA

Plate 1, figures 1–3, 6–10; plate 3, figures 7, 11; plate 4, figures 1, 6, 10, 11

The variability of the embryonic chambers of *Lepidocyclina radiata* will be demonstrated mainly with a sequence of equatorial sections prepared from specimens from one sample. These specimens were previously called *L.*

oneataensis. One section (fig. 8, pl. 1) is from an individual with nephrolepidine embryonic chambers, another (fig. 6, pl. 1) resembles the type van der Vlerk has named trybliolepidine, others (figs. 2, 7, pl. 1) are eulepidine, whereas others (figs. 1, 10, pl. 1) are similar to the multilepidine type. Additional sections of "*Cyclolepidina*" were prepared (fig. 9, pl. 1; fig. 11, pl. 3; figs. 1, 6, 8, pl. 4) for comparison. Comparisons of embryonic chambers should be made as suggested on Table 1.

Inasmuch as the embryonic apparati of all the species listed fall within the series found in "*Lepidocyclina oneataensis*" it is logical to include them in one species, provided the other structures of the test are similar. Detailed comparisons demonstrated that all these species have similar external appearance, and equatorial and lateral chambers. Therefore, the first name given which is *Lepidocyclina radiata* (Martin) must be used.

CONCLUSIONS

The evidence presented demonstrates that within one species of *Lepidocyclina* there is extreme variability in the shape of the embryonic chambers. Some specimens referred to *L. radiata* have nephrolepidine embryonic chambers, others have eulepidine chambers, still others have trybliolepidine chambers, and, finally, others have multilepidine chambers. This variability in the shape of the embryonic chambers constitutes one series.

L. pustulosa has been proven to have individuals with bilocular embryonic chambers and others with multilocular embryonic chambers. This constitutes another series. In both series the multilocular kind is common. However, this overlap is not significant if the entire series are known.

Therefore, once series have been demonstrated, they will be useful in grouping species into subgenera. However, it should be evident that certain subgeneric names must be combined. Inasmuch as *Nephrolepidina*, *Eulepidina*, *Trybliolepidina* and *Multilepidina* have been subgeneric names applied to individuals within one species, and, also constitute one series, they all refer to one distinct type. Tentatively, it is suggested that the subgeneric name *Eulepidina* be applied to this series.

Pliolepidina is retained for the series represented by *L. pustulosa*. Although more study is needed, it seems reasonable to retain the subgenera *Polylepidina* and *Lepidocyclina* sensu stricto. Therefore, the genus *Lepidocyclina* would be subdivided into 4 subgenera, namely, 1) *Polylepidina* of the American middle Eocene, 2) *Pliolepidina* of the American middle and upper Eocene, 3) *Eulepidina* of the American upper Eocene, Oligocene and lower Miocene, but also occurring in the Oligocene and Miocene of Europe and the Indo-Pacific region, and 4) *Lepidocyclina* sensu stricto which occurs in the American Oligocene and lower Miocene.

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(see next page for plate explanations)

EXPLANATION OF PLATES

PLATE 1

1–10 *Lepidocyclina* (*Eulepidina*) *radiata* (Martin)
1–8, 10, topotypes of "*L.* (*Eulepidina*) *oneataensis*" Cole; 9, topotype of "*L.* (*Cyclolepidina*) *suvaensis*" Whipple; 1, 6–8, × 40; 2–5, 9, 10, × 20; 1–3, 6–10, central parts of equatorial sections to illustrate the embryonic, periembryonic and initial equatorial chambers; 4, 5, vertical sections; 1–8, 10, locality 13; 9, locality 12.

PLATE 2

1–10 *Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé
1, 3, 4, 6, 9, central parts of equatorial sections to illustrate the embryonic, periembryonic and initial equatorial chambers of specimens identified as *L.* (*P.*) *pustulosa*; 2, 5, 7, 8, 10, central parts of equatorial sections to illustrate the embryonic, periembryonic and initial equatorial chambers of specimens previously identified as *L.* (*P.*) *pustulosa* forma *tobleri*; 1–10, × 40; 1, 3, 4, 9, locality 3; 2, locality 5; 5–8, 10, locality 4.

PLATE 3

1–6, 9, 10 *Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé
1, 2, 5, 6, 10, central parts of equatorial sections to illustrate the embryonic, periembryonic and initial equatorial chambers of specimens previously identified as *L.* (*P.*) *pustulosa* forma *tobleri*; 3, part of the peripheral equatorial chambers of the specimen illustrated as figure 1, plate 2; 4, part of the peripheral equatorial chambers of the specimen illustrated as figure 1, this plate; 9, central part of an equatorial section of a specimen identified as *L.* (*P.*) *pustulosa*; 1–6, 9, 10, × 40; 1, 4, locality 1; 2, locality 2 (U.S.N.M. no. 561124, see: Cole, 1952, pl. 14, fig. 12); 3, locality 3; 5, 6, 10, locality 5; 9, locality 4.

7 *Lepidocyclina* (*Eulepidina*) *radiata* (Martin)
Equatorial section, × 20; locality 13.

8 *Lepidocyclina* (*Eulepidina*) *yurnagunensis* Cushman
Part of an equatorial section, × 40, introduced for comparison of the embryonic and equatorial chambers with those of *L.* (*P.*) *pustulosa*; locality 6.

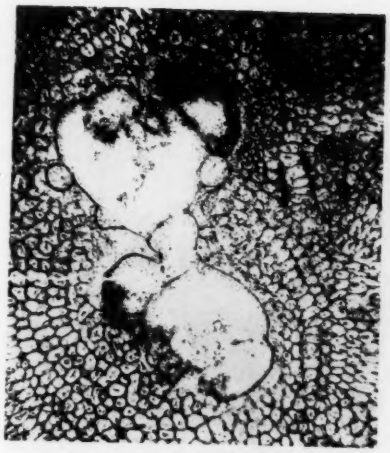
11 *Lepidocyclina* (*Eulepidina*) *radiata* (Martin)
Central part of an equatorial section, × 20; locality 10.

PLATE 4

1–3, 6, 8, 10, 11 *Lepidocyclina* (*Eulepidina*) *radiata* (Martin)
1, 6, central parts of equatorial sections of specimens previously identified as *L.* (*Cyclolepidina*) *suvaensis* Whipple; 2, peripheral equatorial chambers of the specimen illustrated as figure 7, plate 1, previously identified as *L.* (*Eulepidina*) *oneataensis* Cole; 3, peripheral equatorial chambers of the topotype specimen of "*L.* (*C.*) *suvaensis*" illustrated as figure 9, plate 1; 8, vertical section of a topotype of "*L.* (*C.*) *suvaensis*"; 10, central part of an equatorial section of a specimen identified by I. M. van der Vlerk as *L.* (*Nephrolepidina*) *borneensis* Provale; 11, central part of an equatorial section of a specimen identified by I. M. van der Vlerk as *L. luxurians* Tobler; 2–3, 8, 10, 11, × 40; 1, 6, × 20; 1, locality 10; 2, locality 13; 3, 8, locality 12; 6, locality 11; 10, locality 8; 11, locality 9.

4, 5 *Pseudophragmina* (*Proporocyclina*) *zaragosensis* (Vaughan)
4, part of an equatorial section of a specimen with three sets of embryonic chambers; 5, vertical section of a specimen with two or more sets of embryonic chambers; 4, 5, × 40; 4, 5, locality 7.

7, 9 *Lepidocyclina* (*Pliolepidina*) *pustulosa* H. Douvillé
7, 9, central parts of equatorial sections; 9, part of the specimen illustrated as figure 5, plate 2, by reflected light; 7, 9, × 40; 7, 9, locality 4.



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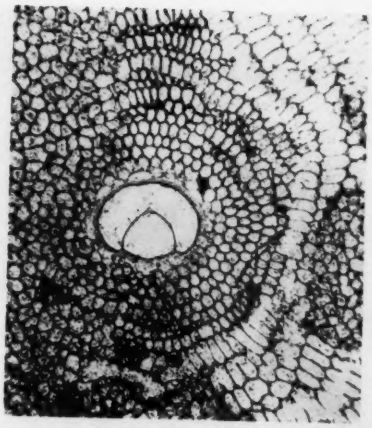

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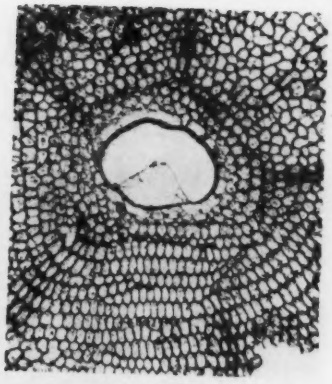

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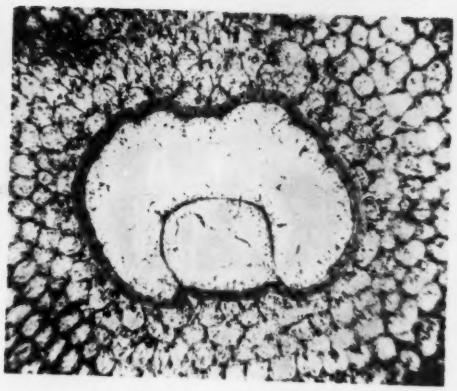

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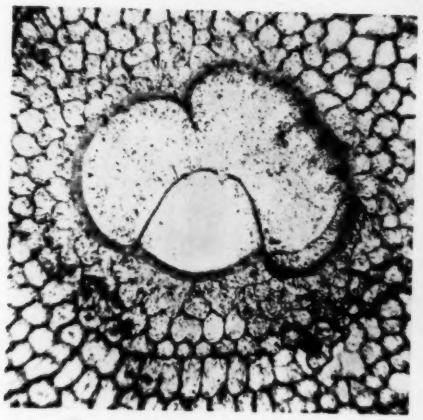

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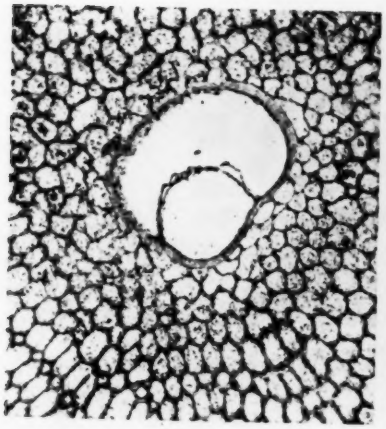

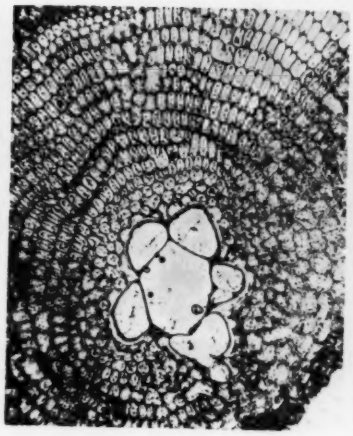

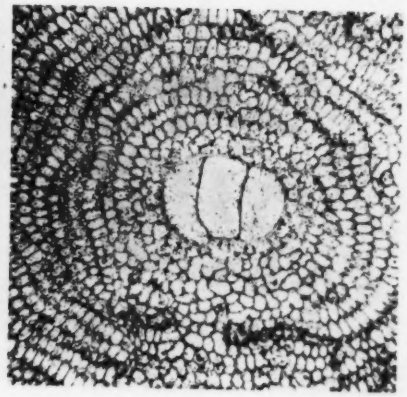

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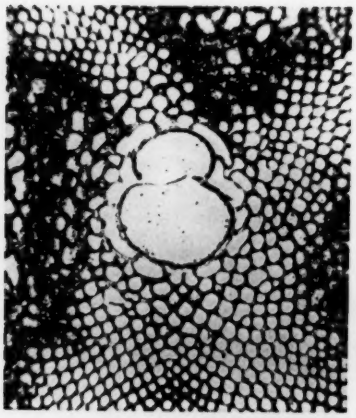

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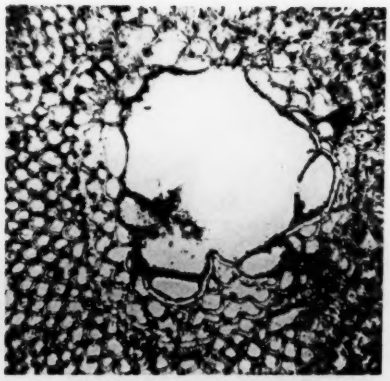

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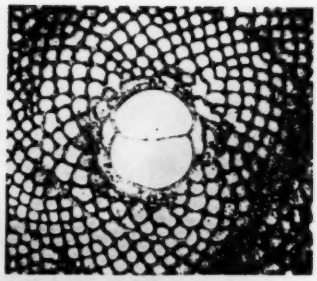

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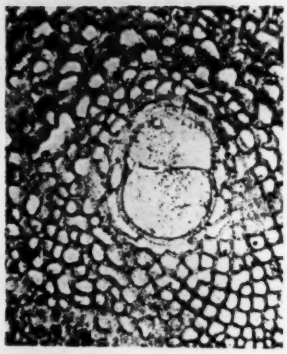

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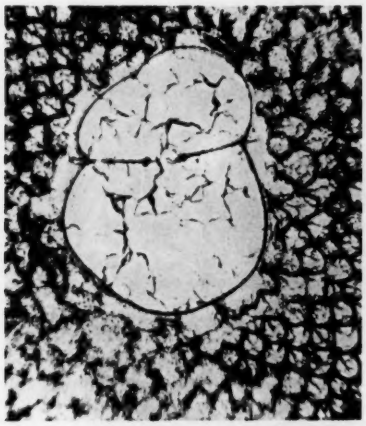

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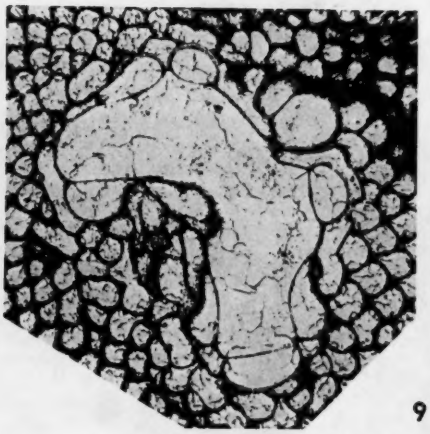

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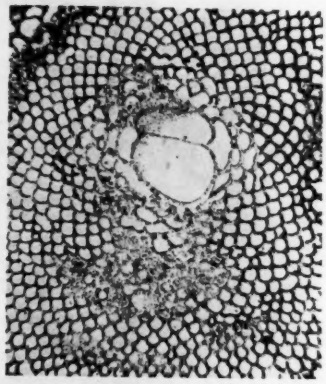

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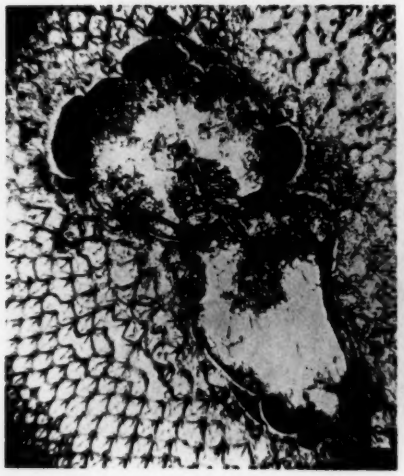

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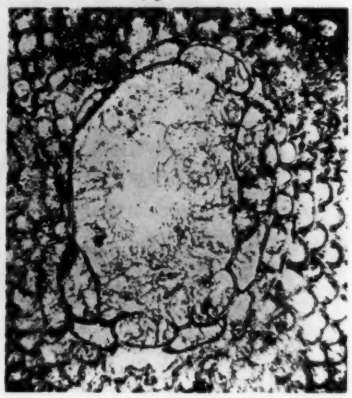

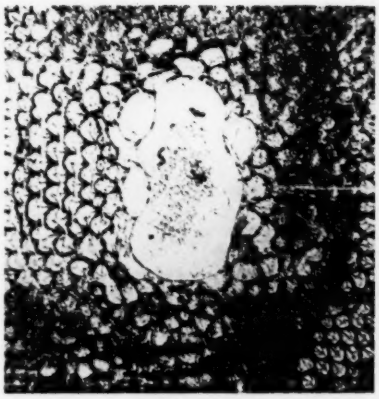

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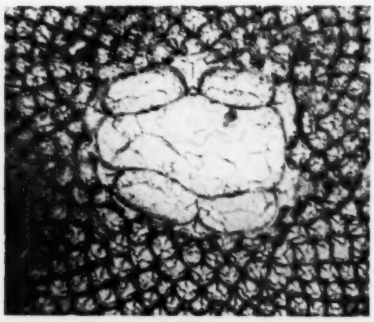

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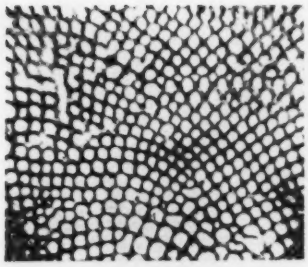

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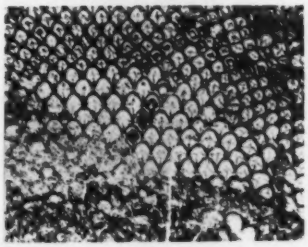

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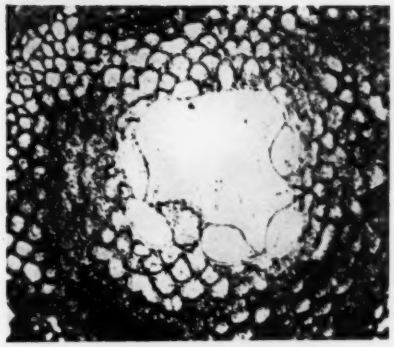

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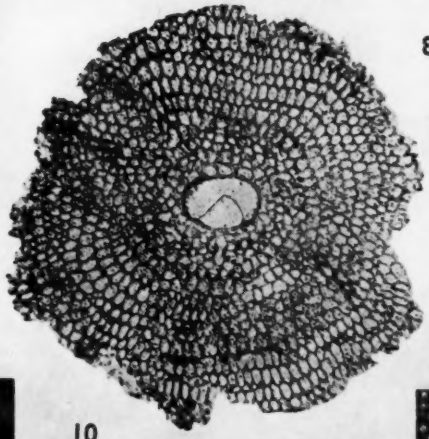

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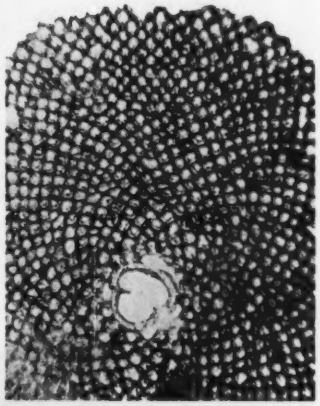

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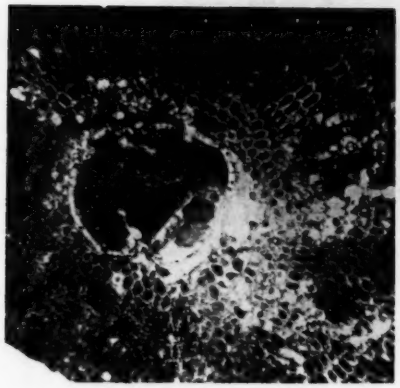

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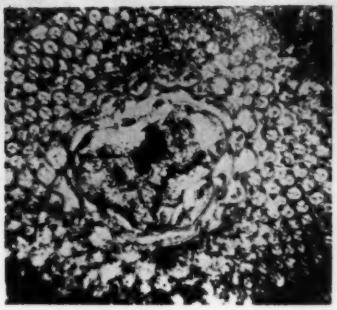

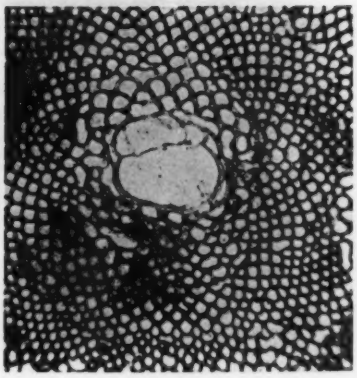

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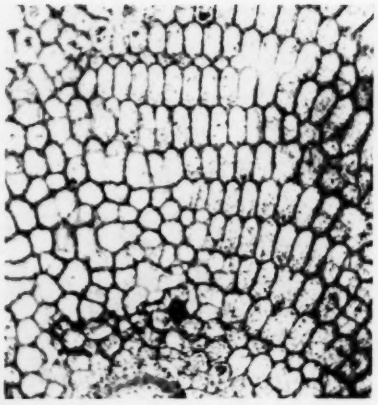

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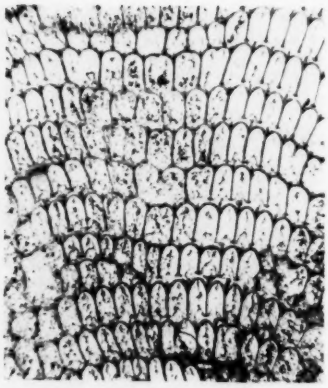

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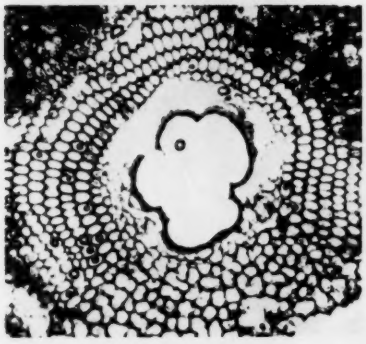

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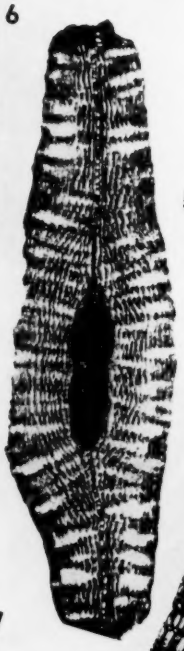

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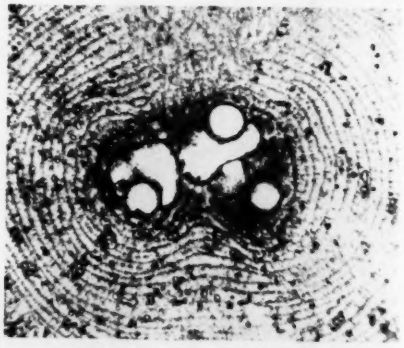

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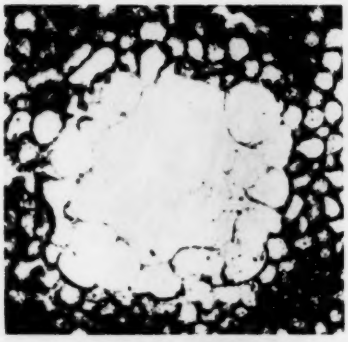

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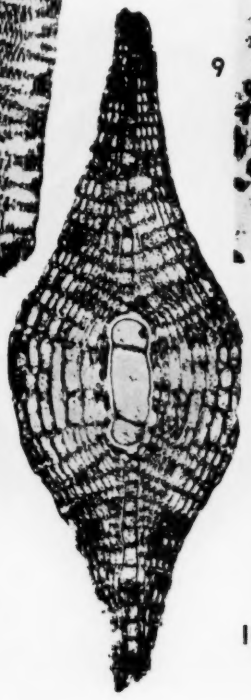

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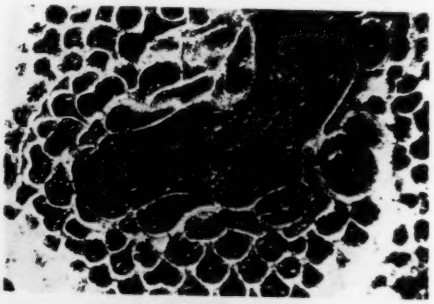

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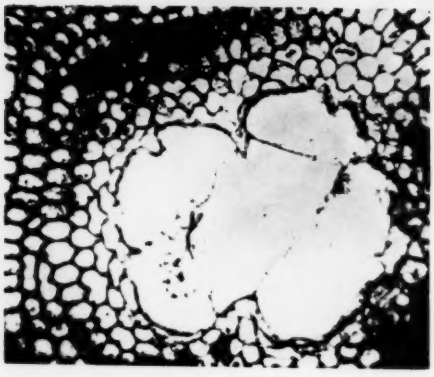

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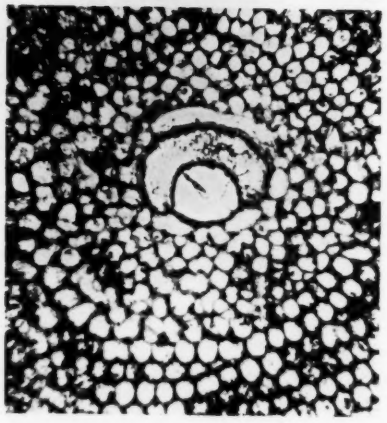

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ABSTRACT: *More than a hundred species of ostracodes are described or listed from the Eocene and Oligocene of Trinidad. One genus and thirty-four species are new, forty-six species have been described previously from the Caribbean and the Gulf Coast. It is shown that the genus* Krithe *can be used for biostratigraphic zonation.*

Eocene and Oligocene Ostracoda of Trinidad

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INTRODUCTION

This study is the fourth in a series on the Tertiary ostracodes of Trinidad. It deals with species from the Lizard Springs, Navet and San Fernando formations and the so-called "*Gaudryina* beds" of Eocene age and the lower Cipero formation of Oligocene age. Previous studies have covered the Paleocene and part of the lower Eocene (van den Bold, 1957*a*), and the lower and possibly part of the middle Miocene (van den Bold, 1957*b*, 1958*b*). Information from these papers has been incorporated in the present report, and, in a few cases where the stratigraphic range of some previously described species was extended into Eocene or Oligocene, no mention of the species has been made in the systematic part. Studies of the planktonic foraminifera by H. M. Bolli (1957*a*, *b*, *c*) and others have been used to establish the stratigraphic ranges of the ostracodes. However, to a certain extent, these ranges are still imperfectly known. The material on which this study is based was provided by Texaco Trinidad, Inc.; permission to publish this information is herewith gratefully acknowledged. The ostracodes were picked out of the samples at their laboratory in Pointe-a-Pierre, so that the stratigraphic position of the samples could not be checked against that of the foraminifera. As a result some ideas, based on the study of older publications had to be changed after new and unpublished data had been received from the geologists and paleontologists working in Trinidad. I am particularly indebted to H. G. Kugler and J. B. Saunders for providing me with this necessary information and for criticism of the initial draft of this paper.

Holotypes and paratypes of the new species have been deposited in the collections of the U.S. National Museum in Washington, D. C., except the types for *Pseudocythere cubensis*, which were deposited in the Geological Museum of Utrecht University, from which institution material was received on loan. In this connection, I thank C. R. Drooger for his kind cooperation.

The illustrations of the species were drawn from photographs, enlarged up to about 160 times. H. V. Howe generously allowed the use of his photographic equipment for this purpose.

ECOLOGY

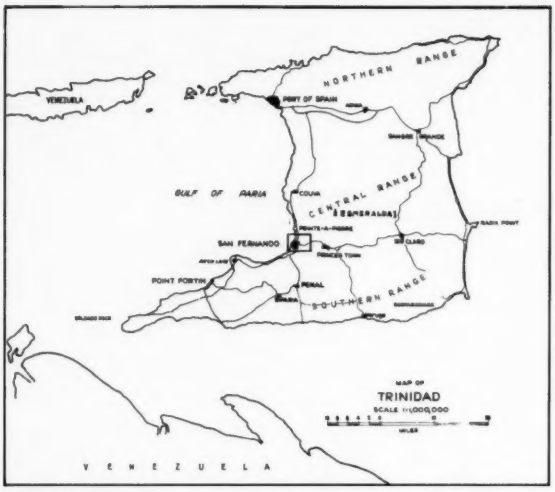
Two types of facies have been found in the Eocene and Oligocene of Trinidad:

1) *Open sea facies:* Represented by the marls and calcareous clays of the Lizard Springs, Navet and Cipero formations, rich in planktonic foraminifera. The ostracodes belong mainly to the genera: *Alatacythere*, *Argilloecia**, *Bairdia**, *Bythocypris*, *Cardobairdia*, *Cythereis?*, *Cytherella**, *Henryhowella**, *Krithe**, "*Krausella*", *Parakrithe** and some species of *Trachyleberis* (species *bollii* and *?hazelae*).

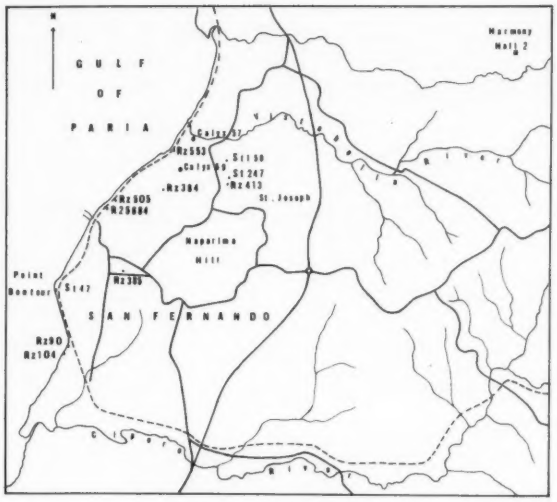
   *Genera marked by an asterisk have their main distribution in open sea facies, but they may also occur in shallow water, near shore deposits.

   Many of the open sea species have fairly long stratigraphic ranges. In the case of smooth forms, which predominate in these deposits, this could be partly due to inability to separate these apparently long-lived species into shorter-lived groups. However, some of the ornamented species remain unchanged over a long span of time (*Alatacythere maerkyi*, *Cythereis? trinidadensis*, *Trachyleberis? hazelae*).

2) *Near shore facies:* Represented by the sandy and silty clays, silts and occasional limestones of the San Fernando formation and the "*Gaudryina* beds", containing more benthonic than planktonic foraminifera. The ostracodes belong to the genera: *Argilloecia**, *Bairdia**, *Bosquetina?*, *Brachycythere*, *Buntonia*, *Cativella*, *Costa*, *Cytherella**, *Cytheropteron*, *Cytherura*, *Eucytherura*, *Hemicythere*, *Hermanites*, *Krithe**, *Loxoconcha*, *Macrocypris*, *Microcythere?*, *Munseyella*, *Paracypris*, *Parakrithe**, *Protobuntonia*, *Pseudocythere*, *Quadracythere*, *Ruttenella*, *Trachyleberis* (species *bermudezi*, *?spiniferrima*, *?hapsida*) and *Xestoleberis**. Most of these shallower water forms have comparatively short stratigraphic ranges, but since they are influenced or even controlled by facies changes, their true ranges are difficult to ascertain. The large horizontal distribution of some of them within a short section of the geological column, however, suggests their usefulness in correlation.



TEXT-FIGURE 1
MAP OF TRINIDAD



TEXT-FIGURE 2
MAP OF SAN FERNANDO AREA

A short discussion of the formations follows. For details the reader is referred to the original descriptions and to later discussions by Kugler (1953), Bolli (1957*a*, *b*, *c*), Suter (1951) and others.

STRATIGRAPHY

LIZARD SPRING FORMATION (Cushman and Jarvis, 1928, pp. 85–103).

The Lizard Springs formation consists of greenish-grey marl and calcareous clay grading into the Navet formation by an increase in calcareous content. The Ramdat marl was originally included with the Navet formation and for that reason no reference was made to it in the paper on the Paleocene ostracoda (van den Bold, 1957*a*). Since then Bolli (1957*a*) has included it with the Lizard Springs formation, as the increase in calcium carbonate takes place after the deposition of the Ramdat marl.

Globorotalia aragonensis zone, Ramdat Marl.

Type sample: Renz 413, location on text-fig. 2 (see also Bolli, 1957*a*, p. 64).

Ostracode fauna: *Cytherella navetensis*, *Argilloecia subcylindrica*, *Bairdia cespedesensis*, *Bairdia cassida*, *Bythocypris guppyi*, *Krithe guatemalensis*, *Krithe cancuenensis*, *Cythereis? trinidadensis*, *Alatacythere maerkyi*.

NAVET FORMATION (Renz, 1942, p. 535).

The Navet formation consists of light grey and greenish grey marls and marly clays with a thickness up to 1000 feet, usually rich in planktonic foraminifera. Bolli (1957*c*, pp. 156–159) has succeeded in establishing seven biostratigraphic zones, based on planktonic foraminifera, which in part coincide with the previously established members (Cushman and Renz, 1948). Charts 1–4 show the correlation of these members with the foraminiferal zones. The Navet includes part of the Wilcox, Claiborne and lower Jackson stages of the Gulf coast of the U.S. and is lower to lower upper Eocene in age.

In this open sea facies of the Navet formation only a small number of ostracode species occur, although specimens may be locally abundant, and most of their representatives have fairly long stratigraphic ranges. However, the Krithinae can be used for subdividing the Navet formation into five ostracode zones (Chart 2).

Globorotalia palmerae zone (Bolli, 1957*c*, p. 156, 158).

Type sample: Esmeralda well 1, core 9386–9405 feet (text-fig. 1). The ostracod fauna is very poorly preserved with only *Krithe guatemalensis*, *Argilloecia subcylindrica* and *Xestoleberis sp.* (not described) positively identified.

Hantkenina aragonensis zone, Friendship Quarry marl.

Type sample: Renz, 336 (Bolli, 1957*c*, p. 158). Ostracode fauna: *Cytherella navetensis*, *Argilloecia subcylindrica*, *Bairdia cespedesensis*, *dolicha*, *Bythocypris guppyi*, "*Bythocypris*" *pykna*, *Cardobairdia ovata*, *Krithe guatemalensis*, *Krithe cancuenensis*, *Parakrithe?* sp. (not described), *Trachyleberis? spiniferrima*.

Other typical samples mentioned by Bolli (1957, p. 158): Kugler sample 8781: *Krithe guatemalensis*, *Krithe saundersi*, *Cythereis? sculptilis*, *Cythereis? trinidadensis*, *Cythereis* ?sp. (not described); Kugler sample 8820: *Cytherella navetensis*, *Argilloecia subcylindrica*, *Krithe guatemalensis*, *Krithe cancuenensis*, *Krithe saundersi*, *Parakrithe?* sp. (not described), *Cytheropteron trinidadensis*, *Trachyleberis bollii*, *Cythereis?* sp. (not described); Kugler sample 8823: "*Krausella*" aff. *minuta*, *Krithe guatemalensis*, *Krithe cancuenensis*, *Krithe saundersi*, *Parakrithe?* sp. (not described); Kugler sample 8911: *Krithe cancuenensis*, *Krithe saundersi*, *Trachyleberis bollii*, *Cythereis?* sp. (not described), *Henryhowella* sp. (not described).

Globigerapsis kugleri zone, Dunmore Hill marl.

Type sample: Renz 476 (Bolli, 1957*c*, p. 158). Ostracode fauna: *Cytherella navetensis, Bairdia cespedesensis, "Krausella"* aff. *minuta, Krithe saundersi, Henryhowella* sp. (not described).

Other sample (Bolli, 1957*c*, p. 158): Kugler 8821, *Cytherella navetensis, Argilloecia subcylindrica, Bairdia cespedesensis, Bythocypris? cancanaensis, "Bythocypris" pykna, Krithe cancuenensis, Krithe saundersi, Parakrithe?* sp. (not described), *Trachyleberis? hazelae, Henryhowella* sp. (not described).

Globorotalia lehneri zone, Fitt Trace marl.

Type sample: Ks 233 (Bolli, 1957*c*, p. 158). Ostracode fauna: *Cytherella navetensis, Argilloecia subcylindrica, Bairdia cespedesensis, Bairdia dolicha, Bairdia cassida, Bythocypris? cancanaensis, "Bythocypris" pykna, "Krausella"* aff. *minuta, Krithe cancuenensis, Krithe saundersi, Parakrithe elongata, Trachyleberis bollii, Cythereis? trindadensis, Henryhowella* sp. (not described), *Uroleberis* aff. *ranikotiana.*

Other samples (Bolli, 1957*c*, p. 158): Kugler sample 8780, *Cytherella navetensis, Argilloecia subcylindrica, Bairdia cassida, Krithe saundersi, Krithe crassicaudata, Trachyleberis bollii*; Kugler sample 8815, *Cytherella navetensis, Argilloecia subcylindrica, Bythocypris guppyi, Krithe saundersi, Ambocythere* sp. (not described); Kugler sample 8822, *Cytherella navetensis, Bairdia cespedesensis, Argilloecia subcylindrica, Krithe saundersi, Cythereis?* sp. (not described). The Navet river marl, type sample Rohr 4347a, is considered to be of the same age: *Cytherella navetensis, Argilloecia subcylindrica, Bairdia* sp., *Krithe cancuenensis, Krithe saundersi, "Krausella"* aff. *minuta, Trachyleberis? hazelae, Xestoleberis* sp. (not described).

Porticulosphaera mexicana zone, Penitence Hill marl.

Type sample: Renz 385, text-fig. 2 (Bolli, 1957*c*, p. 158). Ostracode fauna: *Cytherella navetensis, Bairdia cespedesensis, Bairdia* sp. (not described), *Bythocypris guppyi, Cardobairdia ovata, Argilloecia* sp., (not described), *Krithe saundersi, Krithe crassicaudata, Parakrithe elongata, Trachyleberis bollii, Alatacythere maerkyi, Xestoleberis* sp. (not described). As the original type locality is no longer accessible, Bolli (1957*c*, p. 158) replaced it by Kugler, sample 8814: *Cytherella navetensis, Argilloecia* sp. (not described), *Bairdia cassida, Krithe saundersi, Trachyleberis? hazelae.*

Truncorotaloides rohri zone (Bolli, 1957*c*, p. 159).

Additional material from this zone, the type sample of which was not available, was received from J. B. Saunders. Sample: Esmeralda well 1, 380–394 feet core. Ostracode fauna: *Argilloecia subcylindrica, Krithe saundersi, Krithe crassicaudata, Parakrithe elongata, Parakrithe?* sp. (not described) *Trachyleberis? hazelae, Ambocythere elongata, Ambocythere* sp. (not described), *Uroleberis* aff. *ranikotiana.*

Globigerapsis semiinvoluta zone, Hospital Hill formation.

Type sample: Renz 75 (Bolli, 1957*c*, p. 159). Ostracode fauna: *Cytherella navetensis, Bairdia cespedesensis, Bythocypris guppyi, "Bythocypris" pykna, Krithe elongata, Krithe saundersi, Krithe crassicaudata, Parakrithe elongata, Trachyleberis? hazelae, Cythereis? trinidadensis, Henryhowella asperrima, Alatacythere maerkyi.*

Other samples (see Bolli, 1957*c*, p. 159): Kugler sample 8829, *Argilloecia* aff. *alexanderi, Eucythere* sp. (not described), *Krithe* sp. (indet), *Ambocythere elongata, Trachyleberis bermudezi, Trachyleberis? hazelae*; Kugler sample 8832, *Cytherella harmoniensis, Bythocypris guppyi, Argilloecia* aff. *alexanderi, Krithe crassicaudata, Krithe saundersi.*

Pointe-a-Pierre formation (Waring, 1926, p. 39).

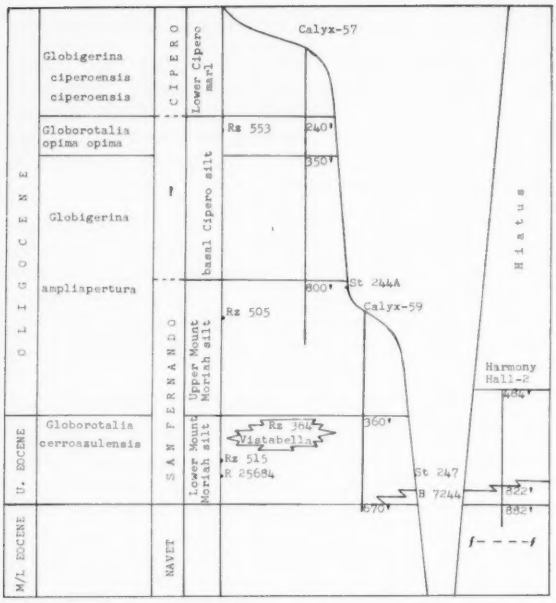
In the gritty sandstones and sandy clays of the Pointe-a-Pierre formation no ostracodes have been found. However, in silty sandy clays, which are believed to be associated with this formation, the so-called "*Gaudryina*" beds, a fairly well preserved ostracode fauna occurs, which bears some resemblance to the fauna of the Concepcion formation (lower and middle Eocene) of the Maracaibo basin (see Kuyl, Muller and Waterbolk, 1955, fig. 7). *Helicolepidina* cf. *spiralis* and *Tremastegina senni* point to a possible middle Eocene age (Kugler, 1953, p. 44). The best preserved fauna was found in Trinidad Petroleum Development's Esmeralda well 1 and in some core holes in the Biche and Charuma areas. The difference of this fauna with the Navet formation of approximately the same age is striking and apparently ecological conditions were not greatly different from those prevailing during the deposition of the San Fernando formation with the fauna of which the "*Gaudryina* beds" have many genera in common.

"*Gaudryina* beds".

Type: Esmeralda well 1, core from 3052–3071 feet. Position of well: N 270297 links, E 415 893 links (Trinidad Government Cadastral coordinates). Ostracode fauna: *Cytherella mexicana* Cushman?, *Bairdia* sp. (not described), *Bythocypris? cancanaensis, Munseyella* sp., *Munseyella israelskyi, Trachyleberis spiniferrima, Costa* n. sp., aff. *barri* (not described), *Costa* n. sp., aff. *harmoniensis* (not described), *Hermanites* sp., *Buntonia alabamensis, Buntonia seminuda, Bosquetina? concepcionensis, Loxoconcha claibornensis.* In a core 2630–2650: less typical sample: *Eucythere* sp., *Occultocythereis?* sp., *Eucytherura* sp., *Bairdia machaquillaensis* was not in this sample but occurs in typical "*Gaudryina* beds" elsewhere.

San Fernando formation (Guppy, 1866, p. 570–590).

The San Fernando formation is made up of silts and sands, with conglomerates often at the base, and lenses of clay and orbitoidal limestone. Total thickness up to 800 feet. The lower part of the formation belongs to the *Globorotalia cerroazulensis* zone and can be correlated with the upper Jackson of the U. S. Gulf Coast. The



TEXT-FIGURE 3

Stratigraphic correlation between Calyx well holes 57 and 58, Harmony Hall well 2 and surface samples in the San Fernando area.

ostracode fauna also shows relationship to that of the Pauji formation (upper Eocene) of the Maracaibo basin. The lithological subdivisions shown on Tables 1–4 are those found locally near the type area of Mount Moriah Hill in the northern part and north of the borough of San Fernando. The distribution of the ostracodes is mainly based on their occurrence in samples collected from railway cuts north of San Fernando railway station and in Calyx holes 57 and 59 (text-fig. 2). The lenticular bed of orbitoidal limestone (Vistabella) mentioned by Waring (1926, p. 47) as lying 200 feet above the calcareous beds and which contains the larger foraminifera described by Vaughan and Cole (1941) is tentatively plotted into this section. The position of Harmony Hall well 2 is based entirely on the occurrence of ostracodes as is the position of Barr sample 7244, from St. Joseph village, northeast of San Fernando.

Lower Mount Moriah silt, non-calcareous zone.

Type sample Renz 515 (text-fig. 3). Because of the better development of the ostracode fauna, this sample is replaced by the nearby type locality of the *Globorotalia cerroazulensis* zone (Bolli, 1957, p. 160), *Globorotalia cocoaensis* zone, Rohr sample 25604 (text-figs. 2–3): *Cytherella stainforthi, Bairdia caraibeensis, Bairdia* sp. B., *Bairdia* sp. C. *Krithe hiwanneensis, Krithe saundersi, Munseyella reticulata, Brachycythere harmoniensis, Costa harmoniensis, Costa lehneri, Costa barri, Jugosocythereis vicksburgensis, Echinocythereis okeechobiensis, Trachyleberis? reticulospinosa, Trachyleberis? hapsida, Cativella moriahensis, Eucytherura kugleri, Xestoleberis chamela.*

Lower Mount Moriah silt, *Globorotalia cerroazulensis* zone.

Stainforth sample 247 (text-figs. 2, 3): *Cytherella* aff. *pulchra, Costa lehneri, Costa harmoniensis, Loxoconcha wagneri, Eucytherura kugleri.*

Upper Mount Moriah silt, calcareous zone.

Type sample, Renz 505 (text-figs. 2–3), *Globigerina ampliapertura* zone Loc. N 237.430 links, E 356800 links. Ostracode fauna: *Cytherella* aff. *pulchra, Argilloecia nutusa, Krithe saundersi, Krithe cubensis, Krithe elongata, Parakrithe? ovata, Loxoconcha wagneri, Cytheropteron montgomeryensis, Cytheropteron? trinidadensis, Cytherura hermesi, Xestoleberis moriahensis*; Stainforth sample 244A, *Cytherella* aff. *pulchra, Cytherella stainforthi, Argilloecia nutusa, Krithe hiwanneensis, Parakrithe? ovata, Costa harmoniensis, Henryhowella asperrima, Trachyleberis bermudezi, Cytherura hermesi, Cytheropteron montgomeryensis, Loxoconcha wagneri, Xestoleberis moriahensis.*

Boca de Serpiente marl (Maury, 1929, p. 100, Soldado Rock).

Type sample: Kugler 3692, for location see Kugler, 1938 (Bed 10). Ostracode fauna: *Cytherella harmoniensis, Cytherella* aff. *pulchra, Cytherella serpentiensis, Bairdia cespedesensis, Bairdia inequivalvis, Bairdia* sp. A., *Ruttenella ovata, Trachyleberis? reticulospinosa, Trachyleberis? hapsida, Trachyleberis bermudezi, Costa meka, Henryhowella asperrima, Cytherura vistabellensis, Eucytherura kugleri, Xestoleberis moriahensis, Xestoleberis* sp.; Kugler sample 3741; south coast of Soldado Rock, Bed 4 of Kugler, 1938, *Globorotalia cerroazulensis* zone: *Cytherella* aff. *pulchra, Cytherella harmoniensis, Argilloecia* cf. *alexanderi, Bairdia cespedesensis, Krithe hiwanneensis, Krithe cubensis, Parakrithe? ovata, Microcythere?* sp., *Munseyella reticulata, Ruttenella ovata, Trachyleberis bermudezi, Costa harmoniensis, Henryhowella asperrima, Hemicythere crystalriverensis, Loxoconcha wagneri, Cytherura hermesi, Eucytherura kugleri, Eucytherura tricornis, Cytheropteron montgomeryensis, Paracytheridea* sp., (not described), *Xestoleberis moriahensis, Xestoleberis chamela, Xestoleberis dumblei.*

Vistabella marl.

Type sample: Renz 384 (text-figs. 2–3), Loc. N. 238220 links, E 359630 links. Ostracode fauna: *Cytherella stainforthi, Argilloecia* aff. *alexanderi, Bairdia* sp., *Ruttenella ovata, Krithe hiwanneensis, Krithe cubensis, Parakrithe? ovata, Costa barri, Costa harmoniensis, Costa meka, Henryhowella asperrima, Munseyella minuta, Cytherura vistabellensis, Eucytherura tricornis, Cytheropteron montgomeryensis, Xestoleberis moriahensis, Xestoleberis chamela.*

Basal Cipero silt.

Type sample: Stainforth sample 47 (text-fig. 2), *Globigerina ampliapertura* zone. Ostracode fauna: *Cytherella stainforthi, Cytherella* aff. *pulchra, Cytherella* sp. A, *Argilloecia nutusa, Argilloecia* cf. *alexanderi, Bairdia cespedesensis,*

Krithe hiwanneensis, Costa lehneri, Costa meka, Cativella moriahensis, Hermanites aff. *H. paijenborchiana, Henryhowella asperrima, Munseyella reticulata, Munseyella minuta, Cytherura vistabellensis, Cytherura byramensis, Cytherura* sp., *Loxoconcha wagneri, Loxoconcha jacksonensis, Xestoleberis moriahensis*; Renz sample 553 (text-figs. 2–3), *Globorotalia opima opima* zone *Cytherella* aff. *pulchra* and var., *Cytherella stainforthi, Cytherella* sp. A, *Argilloecia nutusa, Bairdia cespedesensis, Henryhowella asperrima, Costa lehneri, Krithe hiwaneensis, Loxoconcha wagneri, Xestoleberis chamela.*

CIPERO FORMATION (Cushman and Renz, 1945, p. 1–75).

In the San Fernando area the boundary between the San Fernando formation and the Cipero formation is transitional: the silts and sandy clays of the San Fernando formation persist as high as the *Globorotalia opima opima* zone. Higher in the section the Cipero consists of marly clays and marls with a rich planktonic fauna which was used by Bolli (1957*b*, p. 103) to subdivide the Cipero formation into eleven biostratigraphic zones, four of which represent the Oligocene. With the incoming of open sea conditions the ostracode fauna decreases in the number of species and genera with the genera *Cytherella, Bairdia* and *Krithe* predominating, and it shows some similarity to the fauna of the Navet formation. The genus *Krithe* can be used to subdivide the Cipero formation into biostratigraphic zones (Chart 2). Because many samples containing ostracoda have not yet been properly placed in the stratigraphic succession, the ranges of the species are based only on their occurrence in those samples which have been determined as belonging, to Bolli's biostratigraphic zones. Unfortunately no material from Bolli's type localities has been available and therefore the fauna of the individual localities has not been listed. In many cases the stratigraphic ranges of the species will be found to be incomplete. Some of the samples through the stratigraphic succession on which the distribution of the ostracodes has been based are:

Renz sample 104, *Globigerina ampliapertura* zone; Renz sample 90, *Globorotalia opima opima* zone (former type locality of Renz and Stainforth's *Globigerina concinna* zone); Saunders samples 845, 847, *Globorotalia kugleri* zone and many other samples mainly by Renz from the Cipero section along the west coast of Trinidad south of San Fernando.

In this paper the San Fernando formation has been shown as extending into the lower Oligocene, mainly because Renz has applied the name Mount Moriah silt to the zone penetrated in Calyx hole 57 below about 800 feet and in Calyx hole 59 from the top to about 360 feet. He also included the basal Cipero silt in the San Fernando formation. However, Kugler (personal communication of May 13, 1959) now wants to restrict the San Fernando formation to the upper Eocene and points out that the silts belonging to the *Globigerina ampliapertura* and *Globorotalia opima opima* zones are lithologically distinct from the Mount Moriah silt. He writes: "The latest large scale excavations for a housing scheme east of the San Fernando railway station has clearly shown the block conglomerate at the base of the Cipero silts. Huge slipmasses of Mount Moriah silt are surrounded by 'Basal Cipero silt', which in its lithological aspect can be clearly differentiated from the Eocene Mount Moriah silt, hence also from the San Fernando formation. This unconformity is of fundamental importance for there are many indications that lower Oligocene deposits may be completely missing and that an upper Oligocene sea transgressed on upper Eocene sediments." Since it would be very difficult and completely outside the scope of this work to incorporate these new ideas in the range charts and in the correlations on text-figure 3, I have left the San Fernando formation partially extending into the lower Oligocene. As pointed out above, however, this is not in agreement with the latest views of Trinidad geologists.

SYSTEMATIC DESCRIPTIONS

Class CRUSTACEA
Order OSTRACODA Latreille
Suborder PLATYCOPA Sars
Family CYTHERELLIDAE Sars
Genus CYTHERELLA Jones, 1849

Cytherella navetensis van den Bold, **new species**
Plate 1, figure 1a–e

Cytherella sp., VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 1, p. 4, pl. 2, fig. 1.

Carapace large, ovate, thick-shelled. Anterior end of the right valve broadly rounded, dorsally slightly more narrow than ventrally; dorsal margin convex, nearly straight in posterior third, greatest height just anterior to the middle, converging towards the ventral margin, which has a shallow concavity just behind the middle; posterior end low, obliquely and narrowly rounded. Left valve highest in anterior half, where dorsal and ventral margin are nearly parallel. Anterior end broadly and obliquely rounded; dorsal margin nearly straight in anterior half, slightly convex and sloping down towards the low posterior end behind the middle; ventral margin nearly straight; posterior end obliquely rounded, more narrowly rounded in the upper part.

Strongest overlap of the right valve in the anterior part of the dorsal margin. Dorsal view with blunt posterior end in the right valve, greatest width just behind the middle.

Dimensions: Holotype, right valve: length 1.50 mm; height 0.91 mm; width 0.31 mm., from Renz sample 336. Paratype, left valve: length 1.50 mm.; height 0.83 mm.; width 0.28 mm., from Renz sample 336. Complete carapace: length 1.25 mm.; height 0.77 mm.; width 0.46 mm., from Barr 6872, Lizard Springs formation.

This species occurs throughout the Navet formation, highest occurrence in the Hospital Hill marl, lowest occurrence in the upper Lizard Springs formation. A

few specimens have been found in the San Fernando formation, but the difference in preservation with the rest of the fauna suggests that they are reworked there.

Holotype: A right valve from Renz sample 336, Friendship Quarry marl, Navet formation, *Hantkenina aragonensis* zone, U.S.N.M. no. 563469; paratypes: U.S.N.M. nos. 563470 and 563471.

Cytherella harmoniensis van den Bold, **new species**
Plate 1, figure 2a–c

Carapace ovate, both ends broadly rounded, dorsal and ventral margin roughly parallel, greatest height just in front of the middle.

Female: Anterior end broadly rounded, dorsal margin convex in right valve, slightly sinuate in the left; ventral margin nearly straight; posterior end broadly and obliquely rounded, slightly more narrowly below the middle. Overlap of the right valve strongest along dorsal margin just anterior to the middle and along the ventral margin; very little overlap at posterior end; in the anterior end the overlap is largely obscured by a carina in the left valve. Dorsal view wedge-shaped, posterior end wide, broadly rounded, greatest width about one-third from the posterior end.

Male: About the same shape as the female, but posterior end more obliquely rounded in side view. Dorsal view with narrow, wedge-shaped anterior and posterior ends. Greatest width about one third from behind.

Dimensions: Holotype, female: length 0.87 mm.; height 0.57 mm.; width 0.40 mm. Paratype, male: length 0.85 mm.; height 0.56 mm.; width 0.36 mm.

The species occurs throughout the upper Eocene in the San Fernando formation and in the Hospital Hill marl of the Navet formation. In the Oligocene it is apparently replaced by a related species which has been called *Cytherella* sp. aff. *C. sylverinica* Howe and Law (van den Bold, 1958*b*, p. 396, pl. 1, fig. 1a, b).

Holotype: A female carapace from Harmony Hall well no. 2, 601–613 feet, upper Eocene, San Fernando formation, U.S.N.M. no. 563472; paratypes: U.S.N.M. no. 563474.

Cytherella stainforthi van den Bold, **new species**
Plate 1, figure 3a–c

Female: Carapace ovate, highest in the middle, both ends broadly rounded. Dorsal margin with slightly concave anterior slope in the left valve and broadly convex in the right, ventral margin strongly convex. Right valve overlapping the left along the entire periphery with strongest overlap along the ventral margin and anterodorsally. The left valve has about the same shape as the right, but the greatest height lies slightly more posteriorly. Dorsal view elongate pear-shaped, posterior end wide, broadly rounded, clearly showing the overlap of the right valve; anterior end relatively wide and blunt, narrowly rounded. Greatest height about one third from behind, sides slightly concave in front of the middle.

Male: Ovate, higher in front than behind, greatest height just in front of the middle. Anterior end broadly rounded; dorsal margin in both valves almost straight in front of the greatest height, convex and sloping down behind; posterior end narrowly rounded below the middle; ventral margin almost straight in both valves, with a slight concavity just behind the middle in the right valve. Dorsal view narrower than the female, especially the posterior end.

Dimensions: Holotype, female: length 0.68 mm.; height 0.46 mm.; width 0.36 mm. Paratype, male: length 0.67 mm.; height 0.45 mm.; width 0.31 mm.

The species closely resembles *Cytherella texana* Stadnichenko (1927, p. 242, pl. 39, fig. 18) especially as figured by Sutton and Williams (1939, p. 562, pl. 64, figs. 14, 15) and Stephenson (1946, p. 307, pl. 42, figs. 8,9), but differs by a slight concavity of the anterodorsal margin and the smaller amount of overlap along the dorsal margin.

Cytherella sp. van den Bold (1957*b*, p. 235, pl. 1, fig. 3, 1958*b*, p. 396) is closely similar, but has a stronger convexity of the ventral margin and stronger overlap of the right valve in the anterior part of the dorsal margin, besides being slightly higher.

The species has been named in honour of R. M. Stainforth who did much of the initial work on the planktonic foraminifera of Trinidad.

Distribution: Throughout the San Fernando formation and in the lower Cipero formation, highest occurrence observed was in the *Globigerina ciperoensis ciperoensis* zone. In the *Catapsydrax dissimilis* zone it is replaced by the above mentioned *Cytherella* sp.

Holotype: A complete female carapace from Stainforth sample 47, basal Cipero silt, *Globigerina ampliapertura* zone, U.S.N.M. no. 563474; paratypes: U.S.N.M. no. 563475.

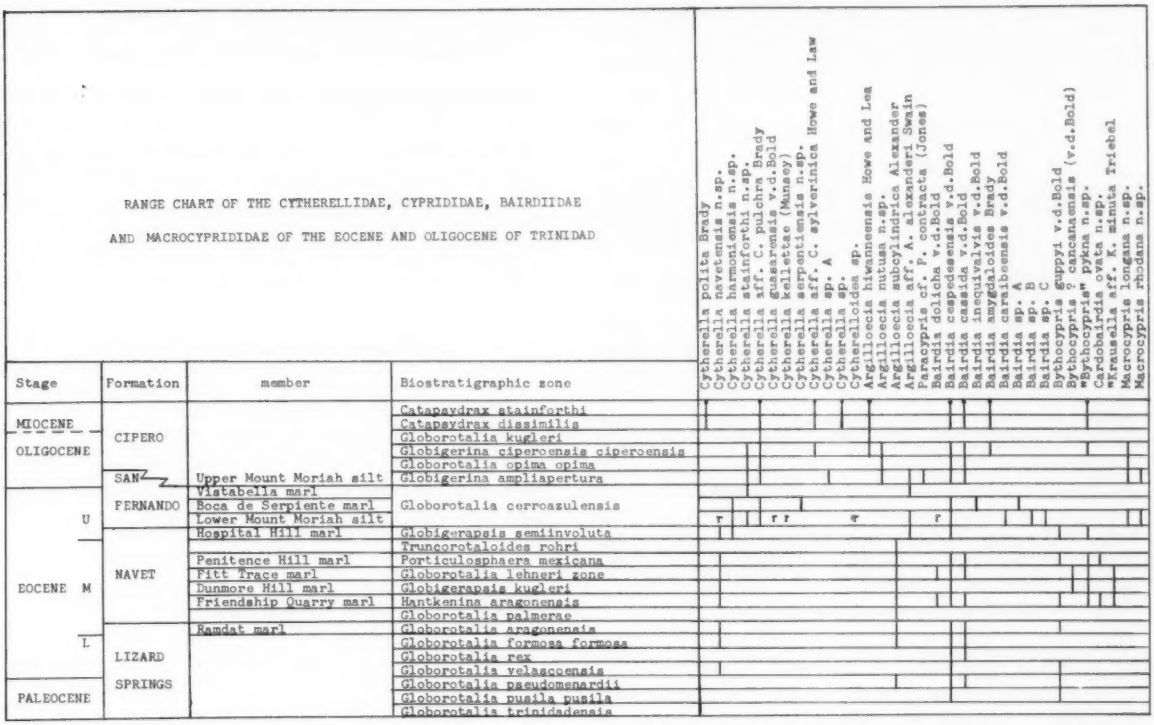
Cytherella sp. aff. **Cytherella pulchra** Brady

Cytherella sp. aff. *C. pulchra* Brady. – VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 3, p. 235, pl. 1, fig. 1.

A species which at the present time cannot be separated from the species described previously from the Oligo-Miocene and which is possibly identical to *Cytherella* sp. (Howe and Chambers 1935, p. 6, pl. 4, figs. 17, 18, pl. 5, figs. 11–12) occurs in the upper Eocene and lower Oligocene. Together with it sometimes occurs a form which has been called *Cytherella* aff. *pulchra* var., and which distinguishes itself by concave ventral and dorsal margins. This form occurs only occasionally and does not merit a specific name. It is possibly a local variant of the common species of the San Fernando formation.

CHART 1

RANGE CHART OF CYTHERELLIDAE, CYPRIDIDAE, BAIRDIIDAE AND MACROCYPRIDIDAE.



Cytherella guasarensis van den Bold

Cytherella guasarensis VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 1, p. 4, pl. 1, fig. 1a–d.

This species occurs reworked in the San Fernando formation, mainly in a zone at the base of the formation, in Harmony Hall well 2 at 822–852 feet.

Cytherella kellettae (Munsey)

Platella kellettae MUNSEY, 1953, Jour. Pal., vol. 27, no. 1, p. 5, pl. 1, fig. 4. – VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 1, p. 4, pl. 1, fig. 2a, b.

This species has also been found reworked in the San Fernando formation. It may be worth while to assign this form, together with related species like: *Cytherella jonesiana* Bosquet, *Cytherella pustulosa* Keij, *Cytherelloidea vanveeni* van den Bold (which should be *C. vanveenae*), *Cytherella praesulcata* Lienenklaus, *Cytherina gyrosa* Roemer etc., to a different genus. The genus *Platella* does not fit the requirements to include these forms, which appear to be intermediate between *Cytherella* and *Cytherelloidea*.

Cytherella serpentiensis van den Bold, **new species**
Plate 1, figure 4a–b

Carapace elongate ovate, highest in the middle. Anterior end broadly rounded, ventral margin regularly and slightly convex; dorsal margin slightly convex and almost parallel to the ventral margin in the anterior part, more strongly convex and converging towards the ventral margin in the posterior part; posterior end formed by the upturned continuation of the ventral margin, narrowly rounded above the middle. Right valve only slightly larger than the left and overlapping it very slightly along the entire periphery. Dorsal view lanceolate, widest behind the middle, ends compressed.

Dimensions: Length 0.64 mm.; height 0.38 mm.; width 0.27 mm.

This small and narrow form looks more like a male or a young moult than like a female. It has, however, been found only at one locality, Boca de Serpiente marl, Soldado Rock (upper Eocene) and it is unknown to what other species it could belong.

Holotype: A complete carapace from Kugler sample 3962, Soldado Rock, U.S.N.M. no. 563476; paratypes: U.S. N.M. no. 563477.

?Cytherella mexicana Cushman

?Cytherella mexicana CUSHMAN, 1925, Am. Assoc. Petr. Geol., Bull., vol. 9, no. 2, p. 301, pl. 8, fig. 1a–b (not c).

?Cytherella texana STADNICHENKO, 1927, Jour. Pal., vol. 1, no. 3, p. 562, pl. 64, figs. 14, 15.

?Cytherella sp. STEPHENSON, 1944, Jour. Pal., vol. 18, no. 5, p. 449. – 1946, Jour. Pal., vol. 20, no. 4, p. 307, pl. 42, figs. 8, 9.

The species mentioned in this synonymy are very similar and it is believed to be impractical to separate them. The Trinidad species shows males and females that are very similar to those described by Stephenson, 1946. They have only been found in the "*Gaudryina* beds".

Cytherella sp. **A**
Plate 1, figure 8

Female: Carapace ovate, slightly higher in front than behind, ends broadly rounded, surface finely punctate. Anterior end very broadly rounded, dorsal margin a low flat arch, nearly parallel to the ventral margin, slightly converging posteriorly; ventral margin convex; posterior end broadly rounded in the middle, both slopes rather flat. Right valve overlapping the left along the entire periphery, strongest overlap anterodorsally and anteroventrally. The overlap at the anterior end is partly obscured by a thin carina in the left valve. The left valve has a broadly rounded anterior and a slightly obliquely rounded posterior end; dorsal and ventral margin are about parallel and nearly straight.

Dorsal view slightly irregular, with a slight restriction anterior to the middle, stronger in the left valve than in the right. Greatest width about one third from behind, posterior end wide, broadly rounded.

Male: Highest anteriorly to the middle; broadly rounded anterior end, dorsal margin convex, forming a regular curve down to the low posterior end which is obliquely rounded. Overlap of the right valve strongest anterodorsally. Dorsal view widest about one third from behind, posterior end narrowly rounded, anterior end fairly sharp. The surface of the valves in both sexes is finely and regularly pitted.

Dimensions: Male: length 0.78 mm.; height 0.51 mm.; width 0.38 mm. Female: length 0.87 mm.; height 0.57 mm.; width 0.43 mm.

The species has only been found in Stainforth sample 47 and Calyx hole 57 (*Globigerina ampliapertura* zone).

Genus Cytherelloidea Alexander, 1929

Cytherelloidea sp.

?Cytherelloidea sp. van den Bold, 1937, Micropaleontology, vol. 3, no. 1, p. 5, pl. 4, fig. 1.

The form found in Harmony Hall well 2 at 828–840 feet is very close to the form described from the Paleocene. However, the posterior vertical rib seems to be divided by the two depressions on both sides of the median ridge that continue further backward and cause it to form two nodes with a depression in between and above. In view of the fact that many reworked Paleocene specimens occur in the well mentioned, it is not improbable that this form is also reworked from the Paleocene and that the difference is due to preservation only.

Family Cyprididae Baird
Subfamily Pontocypridinae Müller
Genus Argilloecia Sars, 1866

Argilloecia sp. aff. **Argilloecia alexanderi** Swain

Argilloecia alexanderi Swain, 1948, Maryland Dept. Geol. Mines Water Res., Bull. 2, p. 192, pl. 12, fig. 7.

The species is very close to *Argilloecia alexanderi* as described from the lower Eocene of Maryland. The Trinidad form is slightly more elongate and has not been found lower than upper Eocene. Therefore I prefer to consider this species for the time being as distinct from Swain's.

Argilloecia subcylindrica Alexander

Argilloecia subcylindrica Alexander. – van den Bold, 1957, Micropaleontology, vol. 3, no. 1, p. 5.

A few specimens of this species from the Paleocene have been found in the lower and middle Eocene of the Navet formation. The highest occurrence is in the *Truncorotaloides rohri* zone.

Argilloecia nutusa van den Bold, **new species**
Plate 6, figure 1a–b

Name: derived from *nutus* (L), a nod of the head, because of the characteristic shape of the anterior part of the carapace.

Carapace elongate, highest just in front of the middle, slightly less than half the length in height; it gives the impression of being slightly bent downward at the anterior end, which is still accentuated by the strong overlap of the anterodorsal margin of the right valve. Anterior end irregularly rounded, obliquely rounded below the middle like a boat's prow, narrowly rounded almost angled just above the middle, dorsal part gently convex and forming an obtuse angle with the dorsal margin in front of the greatest height; dorsal margin nearly straight in the male, gently convex in the female, almost parallel to the ventral margin which is sinuate, with a small concavity in and slightly in front of the middle. Posterior end obliquely rounded, blunt, almost truncate in the dorsal part, narrowly rounded near the ventral margin; in the male the ventral rounding is sharper than in the female.

Right valve overlapping the left all around, except in the ventral part of the anterior end. Strongest overlap in front of the obtuse angle between dorsal and anterior margins. Dorsal view lanceolate, widest slightly behind the middle. Posterior end broader in the female than in the male. Places of stronger overlap of the dorsal margin clearly visible in dorsal view.

Muscle scar typical for the genus; marginal area could not be observed in detail, but conforms to the general pattern of the genus.

Dimensions: Holotype, female: length 0.57 mm.; height 0.28 mm.; width 0.23 mm. Paratype, male: length 0.59 mm.; height 0.28 mm.; width 0.21 mm. Variation: length 0.55–0.61 mm.; height 0.26–0.29 mm.; ratio: 1–0.44 mm. to 1–0.50 mm.

A few larger forms which are similar in outline and have the same length/height ratio have been found in Harmony Hall well 2: length 0.67–0.70 mm.; height 0.31–0.34 mm.

This species resembles *Argilloecia obtusa* Lienenklaus (1900, p. 508, pl. 19, fig. 4a, b) from the lower Oligocene of Germany, but the German species has a much blunter anterior end. *Argilloecia caudata* G. W. Müller (1894, p. 508, pl. 12, figs. 6, 23–26) differs in the position of greatest height.

Range: Oligocene, highest occurrence in the *Globigerina ciperoensis ciperoensis* zone.

Holotype: A complete female carapace from Stainforth sample 47, U.S.N.M. no. 563478; paratypes: U.S.N.M. nos. 563479–563482.

Subfamily Candoninae Kaufmann
Genus Paracypris Sars, 1866

Paracypris sp. aff. **Paracypris contracta** (Jones)
Plate 1, figure 5

Bairdia contracta Jones, 1857, Paleontogr. Soc., Monogr., vol. 9, p. 53, pl. 5, fig. 1a–c.

Bairdia cf. *contracta* Jones. – Latham, 1938, Roy. Soc. Edinburgh, vol. 69, pt. 1, no. 4, p. 40, fig. 2.

Paracypris contracta (Jones). – Keij, 1957, Eocene and Oligocene Ostracoda of Belgium, p. 51, pl. 1, figs. 15–17.

The species of *Paracypris* found only in the *Globigerina ampliapertura* zone is so close to the species from the European middle and upper Eocene, that it is difficult to separate them.

Family Bairdiidae Sars
Genus Bairdia McCoy, 1844

Bairdia dolicha van den Bold

Bairdia dolicha van den Bold, 1957, Micropaleontology, vol. 3, no. 1, p. 5, pl. 2, fig. 2a–b.

This species, originally described from the Paleocene of Soldado Rock, also occurs in the middle Eocene of the Navet formation and (possibly reworked) in the San Fernando formation.

Bairdia cespedesensis van den Bold

Bairdia cespedecensis (sic.) van den Bold, 1957, Micropaleontology, vol. 3, no. 3, p. 236.

Dimensions: Length 0.90–1.50 mm.; height 0.60–1.00 mm.

This long-ranging species (Upper Cretaceous—Miocene) occurs regularly in the Navet, San Fernando and Cipero formations.

Bairdia cassida van den Bold

Bairdia cassida van den Bold, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 70, pl. 1, fig. 7. – 1950, Jour. Pal., vol. 24, no. 1, p. 108.

Bairdia exoura van den Bold, 1957, Micropaleontology, vol. 3, no. 1, p. 4, pl. 2, fig. 6. – 1957, *ibid.*, vol. 3, no. 3, p. 236.

Dimensions: Length 1.10–1.50 mm.; height 0.70–1.00 mm.

After comparison of the two species, I believe that they are identical. The species occurs throughout the Eocene and Oligocene and in the lower Miocene (highest in *Globorotalia fohsi barisanensis* zone).

Bairdia machaquillaensis van den Bold
Plate 2, figure 8

Bairdia machaquillaensis van den Bold, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 72, pl. 4, fig. 3.

Dimensions: Length 0.72–0.82 mm.; height 0.43–0.51 mm.

This species of the lower Eocene and Paleocene of Guatemala has been found in "*Gaudryina* beds" of probably middle Eocene age in Trinidad. Figured specimen is from Esmeralda well 1, 1396–1407 feet, possibly not "*Gaudryina* beds".

Bairdia inequivalvis van den Bold

Bairdia inequivalvis van den Bold, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 72, pl. 4, figs. 9, 10.

One specimen, which is similar in outline to the species from the lower Eocene and Paleocene of Guatemala and British Honduras has been found in the upper Eocene of Soldado rock. It is, however, possible that it is reworked there.

Bairdia caraibeensis van den Bold
Plate 2, figure 3

Bairdia caraibeensis van den Bold, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 71, pl. 4, fig. 5.

This species has only been found in Rohr sample 25684, *Globorotalia cerroazulensis* zone, non-calcareous Mount Moriah silt of the San Fernando formation. It was originally described from the upper Eocene of Bonaire and from the lower Eocene of Guatemala.

Bairdia amygdaloides Brady

Bairdia amygdaloides Brady. – van den Bold, 1957, Micropaleontology, vol. 3, no. 3, p. 236, pl. 1, fig. 6a, b.

This species occurs in Trinidad from the *Globigerina ciperoensis ciperoensis* zone upward.

Bairdia sp. **A**
Plate 2, figure 11

Carapace ovate, laterally rather compressed, highest in the middle, surface finely and regularly pitted.

Anterior end obliquely rounded, prow-shaped; dorsal margin regularly arched, posterior end slightly produced subventrally; ventral margin slightly sinuate, almost straight in the centre part. Left valve overlapping the right along the entire periphery except a short distance in the anterior end; amount of overlap about equal everywhere. Dorsal view spindle-shaped, ends slightly compressed, blunt; greatest width in the middle.

Dimensions: Length 0.73 mm.; height 0.46 mm.; width 0.36 mm.

This species has only been found in the upper Eocene of Soldado Rock, Boca de Serpiente marl.

Bairdia sp. **B**
Plate 2, figure 9

Carapace ovate, thick set, of general subdeltoid shape. Left valve strongly overlapping the right along dorsal margin, less along ventral margin, except midventrally where the overlap is stronger. Small amount of overlap near the ends. Because of its shape the species is not easy to distinguish from others described from the European and American Tertiary. *Bairdia oviformis* Speyer, as figured by Stadnichenko (1927, p. 234, pl. 39, figs. 1–3) is fairly similar, but seems to lack the strong overlap of the left valve. The same can be said for *Bairdia subdeltoidea* (von Münster) (Howe, 1934, p. 389, fig. 1a–c). The species has been found sporadically in the San Fernando formation. Figured specimen is from Rohr sample 25684, type locality for the *Globorotalia cerroazulensis* zone.

Dimensions: Length 0.99 mm.; height 0.69 mm.

Bairdia sp. **C**
Plate 2, figure 4

Carapace elongate, highest in the middle. Anterior end obliquely rounded, dorsal margin gently convex, much less than the strongly curved ventral margin; posterior end narrowly rounded in the middle.

This species, of which only a few single valves have been found in Rohr sample 25684, is figured for its unusual shape and for the fact that the overlap of the dorsal margin of the left valve terminates abruptly at the anterior and posterior ends.

Dimensions: Length 0.89 mm.; height 0.55 mm.

Genus BYTHOCYPRIS Brady, 1880

Bythocypris guppyi van den Bold

Bythocypris guppyi VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 1, p. 6, pl. 2, fig. 9.

This species, originally described from the Lizard Springs marl, occurs throughout the Navet formation; its highest occurrence being in the Hospital Hill marl, upper Eocene.

Bythocypris? cancanaensis (van den Bold)
Plate 2, figure 10

Bairdia cancanaensis VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 73, pl. 4, fig. 8.

The species from the lower Eocene of Guatemala and British Honduras was found in the middle Eocene Fitt Trace marl and Dunmore marl of the Navet formation and in the "*Gaudryina* beds" of Esmeralda well 1.

Dimensions: Length 1.08 mm.; height 0.65 mm.

The Trinidad species is slightly smaller than the Central American form, but otherwise quite similar. Originally, it was described as a *Bairdia* but it more probably belongs to *Bythocypris*, although it is slightly intermediate in character.

"Bythocypris" pykna van den Bold, **new species**
Plate 2, figure 1a–d

Female: Carapace elongate ovate, highest in the middle, greatest height about three fifth of the length, widest behind the middle, greatest width about half the length. The margin is strongly folded inwards making it necessary to distinguish between outer margin and outline of the valve. Anterior end very obliquely rounded, margin parallel to the outline, which passes in continuous curve into dorsal and ventral outlines; dorsal outline arched, hinge margin straight, forming a faint angle with anterior and posterior margins; an accomodation groove occurs above the hinge line; posterior outline straight or very slightly concave above the posterior end, which lies just below the middle and is narrowly rounded; posterior margin not quite parallel to posterior outline; ventral outline strongly and regularly convex, ventral margin almost straight, slightly sinuate in front of the middle. Dorsal view elongate egg-shaped, ends narrowly rounded.

Male: Same general shape as the female, but greatest height just anterior to the middle, slightly lower and narrower. Muscle scar area just behind the center, consisting of a circular area composed of 8 or 9 scars.

Shell thick and heavy. Marginal area fairly broad in anterior and posterior end, small vestibule, no pore canals visible. Hinge in the left valve consists of a straight bar above which is an accomodation groove. In the right valve it consists of a groove below which a narrow straight bar occurs, which is slightly thickened and raised at the ends, forming 2 elongate smooth teeth which fit below the bar in the left valve. The left valve is overlapping the right along the entire periphery, amount of overlap about equal everywhere.

Dimensions: Holotype, single left valve of a female from Rohr sample 18192, (Lengua formation, middle Miocene); length 1.02 mm.; height 0.55 mm. Paratype: length 0.91 mm.; height 0.53 mm.; width 0.47 mm.

The heavy shell and the peculiar infolded margin separate this species from the genus *Bythocypris* and suggest relationship to *Pseudophanassymetria* Sohn and Berdan (1952, p. 10) and to *Cardobairdia* n. gen., described below. It differs from the latter by its smooth hinge and simpler muscle scar. It has some resemblance to the genus *Hungarella* Mehes (1911) from the Triassic of Hungary. In the described forms, however, *Bairdia? problematica* Mehes (1911, p. 21, pl. 2, figs. 14–18) and variety *reniformis* (p. 22, pl. 2, figs. 19–23) the number of muscle scars is much greater than in "*Bythocypris*" *pykna*. The species very probably belongs to a new genus.

It occurs infrequently throughout the Navet formation from the Friendship Quarry marl to the Hospital Hill marl. It is absent in the San Fernando formation, but reappears in the Cipero and Lengua formations, where it is also quite rare.

Holotype: A single female left valve from Rohr sample 18192, Lengua formation, U.S.N.M. no. 563483; paratypes: U.S.N.M. nos. 563484 to 563486.

Genus **Cardobairdia** van den Bold, **new genus**

Type species: Cardobairdia ovata van den Bold, new species

Diagnosis: A genus of the Bairdiidae with strongly infolded margin and a hinge consisting of slightly curved elongate sockets at both ends of the dorsal margin of the left valve, separated by a shallow groove, which is obscured by the incurved dorsal margin. Shape ovate; left valve much larger than the right and overlapping along the entire periphery, especially dorsally and ventrally.

Range: Eocene to Miocene (probably much longer).

Cardobairdia ovata van den Bold, **new species**
Plate 2, figure 2a–c

Carapace egg-shaped, highest just anterior to the middle, widest in the middle. Height nearly two thirds of the length, width more than half of the length. Left valve much larger than the right and overlapping along the entire periphery, strongest overlap along dorsal and ventral margin. The margin of the left valve is strongly folded inwards so that in the description it is necessary to make a sharp distinction between margin and outline of the valve. Anterior end obliquely rounded, narrowly below the middle, continuing without angulation into dorsal and ventral outlines; dorsal outline nearly straight in the posterior part, generally arched; ventral outline strongly convex, continuing without angulation in the posterior end, which is narrowly rounded below the middle, nearly straight or slightly concave above, obliquely truncate, forming an obtuse angle with the dorsal outline. The suture between the valves is obliquely rounded in the anterior end; dorsal margin almost straight, ventral margin convex, but not as strongly convex as the ventral outline; posterior margin obliquely rounded. Dorsal and ventral margin converge posteriorly.

Dorsal view spindle-shaped, ends slightly compressed, narrowly rounded. Muscle scar area circular, consisting of about 15 scars, typical *Bairdia*-like. Hinge consists of terminal elongate sockets which are finely denticulate in the left valve; they are separated by a groove which is covered in side view by the inward-curved dorsal margin. Hinge in the right valve not observed. Marginal area fairly narrow, no vestibule was seen, pore canals not observed. The appearance of the marginal area is rather *Cytherella*-like. The shell is very thick and heavy. No sexual dimorphism was observed.

Dimensions: Holotype: length 0.70 mm.; height 0.44 mm.; width 0.39 mm. Variability: length 0.69–0.74 mm.; height 0.43–0.48 mm.; ratio: 1–0.63 mm.

There were two specimens of much larger dimensions (text-figure 4), but of the same shape. Since the hinge was observed in a specimen of the regular dimensions, which is therefore considered an adult, the two other specimens must either be aberrant forms or belong to a different species. Young moults were about 0.62 mm. in length. No single valves occurred, so in order to observe the interior structure attempts were made to open some of the specimens. As the shell is very thick and heavy, these were generally not successful, but in one case a left valve was obtained with the hinge line broken off. The remnants were more or less fitted together and Plate 2, figure 2c is a reconstruction based on the two parts of the valve. Only a few specimens have been found in the Navet formation (Friendship Quarry marl and Penitence Hill marl). The species is much more common in the Miocene Lengua formation. So far it has not been found in the San Fernando and Cipero formations.

Holotype: A complete carapace from Renz sample 385, Penitence Hill marl, Navet formation, U.S.N.M. no. 563487; paratypes: U.S.N.M. nos. 563488 to 563492.

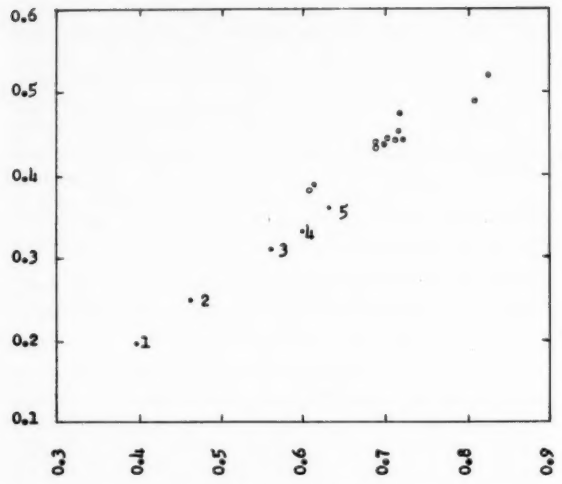
This genus has much in common with *Pseudophanassymetria* Sohn and Berdan (1952, p. 10) especially in the thick non-porous heavy shell and the great difference in valve size. However, *Pseudophanassymetria* is reported to have a smooth hinge. For comparison with "*Krausella*" see under that genus.

Genus Krausella Ulrich, 1894

"Krausella" minuta Triebel
Plate 6, figure 3

Krausella minuta Triebel. – van Veen, 1936, Natuurhist. Maandbl., vol. 25, no. 12, p. 176, pl. 10 figs. 7–15.

The hinge of this species was studied in a few specimens from the upper Cretaceous of Holland. It proved to have almost the same hingement as *Cardobairdia* and appears to be related to this genus. "*Krausella*" *asymmetrica* van den Bold (1946, p. 67, pl. 3, fig. 17) has the same hinge. It seems improbable that the posterior spine as developed in the species mentioned above and in *Krausella*? sp. (Oertli, 1958, p. 1503, pl. 2, figs. 39–41)



TEXT-FIGURE 4

LENGTH / HEIGHT RATIO OF "*Krausella*" AND *Cardobairdia*.

.1 *Krausella* sp., Oertli, Aptian-Albian, Apt, France.
.2 *Krausella minuta* Triebel, Upper Cretaceous, Holland.
.3 *Krausella minuta* Triebel, van den Bold, 1946, middle Eocene, British Honduras.
.4 "*Krausella*" sp. aff. *Krausella minuta* Triebel, middle Eocene, Trinidad.
.5 *Krausella asymmetrica* van den Bold, Miocene, Cuba.
.0 *Cardobairdia ovata* van den Bold, n. sp.

and in the species found in the Navet formation of Trinidad is a generic characteristic, but I would hesitate to assign them to *Cardobairdia* which in all other respects is very similar.

"Krausella" sp. aff. Krausella minuta Triebel
Plate 6, figure 2

?Krausella minuta Triebel. – VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 67, pl. 2, fig. 7.

A few specimens from the Dunmore Hill and Fitt Trace marls are rather similar in outline to "*Krausella*" *minuta* Triebel, but are slightly larger.

Dimensions: Length 0.60 mm.; height 0.33 mm.; width 0.28 mm. The specimen from British Honduras measures length 0.56 mm.; height 0.31 mm.; width 0.26 mm.; and "*Krausella*" *minuta* Triebel length 0.46 mm.; height 0.25 mm.; width 0.24 mm. (text-fig. 4). Moreover the anterior part of the Cretaceous species is shorter. Oertli's species from the upper Albian and lower Aptian is still smaller: length 0.39–40 mm.; height 0.21–22 mm.; width 0.18–19 mm. (measured from his figures). There seems to be a definite trend towards increase in size from the Cretaceous to the Miocene.

Subfamily MACROCYPRIDIDAE Alm
Genus MACROCYPRIS Brady, 1868

Macrocypris longana van den Bold, new species
Plate 1, figure 7a–b

Carapace large, elongate, highest about one third from the anterior end. Anterior margin obliquely rounded, shaped like a prow; dorsal margin regularly arched with only a slight angulation at about one fourth from behind; ventral margin nearly straight, slightly sinuate; posterior end sharply pointed ventrally. Right valve overlapping the left along dorsal and ventral margin and posterior end, strongest overlap in the anterior third of the dorsal margin. Dorsal view elongate, widest in the middle, posterior end pointed, anterior end rather blunt. Dorsal suture strongly undulating, curving to the left in the areas of stronger overlap. Muscle scar area circular with about 18 scars. Only closed carapaces have been found and owing to the thickness of the shell little could be seen of the marginal area.

Dimensions: Holotype: length 1.92 mm.; height 0.67 mm.; width 0.64 mm. Variability: length 1.56–2.08 mm.; height 0.60–0.78 mm.

The name of the species is derived from *longano* (L.), a sausage.

The species differs from *Macrocypris cylindracea* (Bornemann), (= *Bairdia cylindracea* Bornemann, 1855, p. 359, pl. 10, fig. 5; *Nesidea cylindracea* Kuiper, 1918, p. 16, pl. 1, fig. 3) which has the greatest height in the middle.

Holotype: Complete carapace from Harmony Hall well 2, 686 to 698 feet, U.S.N.M. no. 563493; paratypes: U.S.N.M. nos. 563494 and 563495.

Macrocypris rhodana van den Bold, new species
Plate 1, figure 6a–b

Carapace elongate, highest just in front of the middle. Anterior end broadly and slightly obliquely rounded; dorsal margin angled at the greatest height and at about one fourth from the posterior end, the three parts of the dorsal margin nearly straight; ventral margin nearly straight, slightly sinuate in front of the middle; posterior end pointed ventrally. Right valve overlapping the left along the entire periphery, strongest overlap from near the anterior end to about one fourth of the length backward along the dorsal margin, and in the anterior half of the ventral margin. Dorsal suture undulate in dorsal view, curving to the left in the areas of stronger overlap. This feature is brought out in the name, *rhodanos* (Gr.), waving. Dorsal view lanceolate, widest in the middle, both ends compressed. Muscle scar area circular with many scars. Marginal area broad in anterior end, radial pore canals usually divided into three branches.

Dimensions: Holotype: length 1.41 mm.; height 0.55 mm.; width 0.36 mm. Variability: length 1.35–1.74 mm.; height 0.52–0.62 mm.

This species occurs often together with *Macrocypris longana* n. sp., and might be suspected to be the male of that species. Students of Recent ostracodes such as Brady (1868, 1880), Müller (1894) and others agree that there is only very slight sexual dimorphism in *Macrocypris*. Moreover its range is slightly shorter; it has not been found above the *Globigerina ampliapertura* zone.

Holotype: A complete carapace from Harmony Hall well 2, 609–613 feet, U.S.N.M. no. 563496; paratypes: U.S.N.M. nos 563497 to 563500. The species appears to be confined to the upper Eocene and lowermost Oligocene.

Family CYTHERIDAE Baird
Subfamily KRITHINAE Mandelstam (in Bubikyan)
Genus KRITHE Brady, Crosskey and Robertson, 1874

Krithe guatemalensis van den Bold
Plate 3, figure 1a–b

Krithe guatemalensis VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 77, pl. 17, fig. 7a, b, 8a, b.

Krithe guatemalensis VAN DEN BOLD, 1957 (part, female), Micropaleontology, vol. 3, no. 1, p. 7, pl. 1, fig. 5a, b (not pl. 1, fig. 5c–e, see *Krithe cancuenensis* VAN DEN BOLD).

This species extends from the Paleocene to the lower part of the middle Eocene (Friendship Quarry marl, *Hantkenina aragonensis* zone). It was originally described from the Paleocene of Guatemala and British Honduras.

Krithe cancuenensis van den Bold
Plate 3, figure 2a–b

Krithe cancuenensis VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 77, pl. 17, fig. 6a, b.

Krithe guatemalensis VAN DEN BOLD, 1957 (part, male), Micropaleontology, vol. 3, no. 1, p. 7, pl. 1, fig. 5c–e (not 5a, b).

Carapace elongate, highest in front of the middle, widest about the middle. Anterior end rather narrowly rounded; dorsal margin convex, with rather flat central part, angled about one third from behind; posterior part sloping down to the obliquely truncate posterior end; ventral margin slightly convex in the left valve, almost straight in the right. In the right valve the anterior slope of the dorsal margin is slightly concave. The marginal area could not be studied properly due to re-crystallisation of the shell.

Dimensions: Length 0.75 mm.; height 0.35 mm.; width 0.27 mm.

This species which was first (van den Bold, 1957) considered to be the male of *Krithe guatemalensis*, was subsequently found to have a stratigraphic range from lower Eocene (*Globorotalia velascoensis* zone) to middle Eocene (*Globorotalia lehneri* zone). Moreover slight sexual dimorphism has been observed in both *K. guatemalensis* and *K. cancuenensis*.

Krithe saundersi van den Bold, **new species**
Plate 3, figure 3a–b

Krithe bartonensis (Jones). – VAN DEN BOLD, 1946 (part) Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 76, 77, pl. 4, fig. 15b, d (not fig. 15a or c).

A re-examination of the Cuban material shows that the specimens figured in pl. 4, fig. 15a from Raadshooven 276 and Keyser 214 (slide D 27069) are different from the rest, as is the single specimen from Keyser 207 (slide D 27071) which was figured as fig. 15c. The others are not identical with *Cytherideis bartonensis* Jones (1855, p. 50, pl. 5, figs. 2, 3), which was recently re-figured by Keij (1957, p. 85, pl. 8, figs. 11–17).

Female: Carapace elongate subrectangular. Anterior end evenly rounded, passing into dorsal and ventral margin without angulation in the left valve; in the right valve the dorsal portion of the anterior margin has a slight concavity; ventral margin slightly sinuate in the middle, parallel to the central portion of the dorsal margin; posterior end obliquely truncate with the lower part projecting strongly beyond the posterior margin. Left valve larger than the right and overlapping at both cardinal angles, less in the middle of the dorsal margin and ventrally. Dorsal view lanceolate, widest just behind the middle, anterior end pointed, posterior end deeply incised in the middle, sides of the carapace regularly convex.

Male: General outline similar to the female, but longer and the posterior end is more oblique, more pointed and more deeply incised. The preservation is too poor for a proper description of the marginal area.

Dimensions: Holotype, female: length 0.73 mm.; height 0.37 mm.; width 0.32 mm. Variation, female: length 0.66–0.76 mm.; height 0.34–0.40 mm.; male: length 0.78–0.85 mm; height 0.35–0.39 mm.

The male is very similar in outline to *Krithe caudata* van den Bold (1946, p. 76, pl. 4, fig. 17) but much larger. It is, however, possible that the Cuban species was a young moult in which case, of course, the name *Krithe caudata* would have priority. *Krithe implicata* Mandelstam (1958, p. 279, pl. 6, fig. 4) is fairly similar in outline but does not show the characteristic overlap of the left valve. The species has been named in honour of J. B. Saunders, paleontologist of Texaco Trinidad, Inc.

Occurrence: Middle Eocene, Friendship Quarry marl (*Hantkenina aragonensis* zone) to lower Oligocene (*Globigerina ampliapertura* zone).

Holotype: A complete carapace from Renz sample 385, Penitence Hill marl, Navet formation, (*Porticulosphaera mexicana* zone), U.S.N.M. no. 563503; paratypes: U.S.N.M. nos. 563504 and 563505.

CHART 2
RANGE CHART OF KRITHINAE

RANGE CHART OF THE KRITHINAE OF THE EOCENE AND OLIGOCENE OF TRINIDAD

Stage	Formation	member	Biostratigraphic zone
MIOCENE	CIPERO		Catapsydrax stainforthi
			Catapsydrax dissimilis
OLIGOCENE			Globorotalia kugleri
			Globigerina ciperoensis ciperoensis
	SAN FERNANDO	Upper Mount Moriah silt	Globorotalia opima opima
			Globigerina ampliapertura
U		Vistabella marl	Globorotalia cerroazulensis
		Boca de Serpiente marl	
		Lower Mount Moriah silt	
	NAVET	Hospital Hill marl	Globigerapsis semiinvoluta
			Truncorotaloides rohri
EOCENE M		Penitence Hill marl	Porticulosphaera mexicana
		Fitt Trace marl	Globorotalia lehneri zone
		Dunmore Hill marl	Globigerapsis kugleri
		Friendship Quarry marl	Hantkenina aragonensis
			Globorotalia palmerae
L	LIZARD SPRINGS	Ramdat marl	Globorotalia aragonensis
			Globorotalia formosa formosa
			Globorotalia rex
			Globorotalia velascoensis
PALEOCENE			Globorotalia pseudomenardii
			Globorotalia pusila pusila
			Globorotalia trinidadensis

Krithe guatemalensis v.d.Bold
Krithe cancuenensis v.d.Bold
Krithe saundersi n.sp.
Krithe crassicaudata v.d.Bold
Krithe cubensis v.d.Bold
Krithe elongata n.sp.
Krithe trinidadensis v.d.Bold
Krithe hiwanneensis Howe and Lea
Krithe morkhoveni n.sp.
Parakrithe vermunti (v.d.Bold)
Parakrithe waitei n.sp.
Parakrithe elongata n.sp.
Parakrithe ? ovata n.sp.
Parakrithe ? sp.

Krithe crassicaudata van den Bold
Plate 3, figure 7a–e

Krithe crassicaudata VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 78, pl. 7, fig. 2a–f.

Female: Ovate in side view, highest about the middle. Anterior end broadly rounded, dorsal margin broadly arched, sloping down sharply into the fairly acute posterior end; ventral margin strongly convex in the left valve, sinuate in the right and in the latter valve partly obscured by the overhanging tumid portion of the valve. In the right valve the anterior part of the dorsal margin is slightly concave and it is there that the strongest overlap of the left valve occurs. Dorsal view widest just behind the middle, posterior end broad, deeply incised.

Male: Much more elongate than the female, posterior end more truncate. In general characters male and female agree, but the male approaches in shape to *Krithe elongata* n. sp., although it is always much more tumid and higher. Marginal area with a strong loop of the line of concrescence in the anterior part. Only six radial pore canals are visible in the anteroventral area, the upper and lower one of which bifurcate. This anteroventral part is much more irregular than in most species of *Krithe* and the line of concrescence does not parallel the outer margin as is usually the case. Connection of the vestibule with the interior is very narrow.

Dimensions: Female: length 0.83 mm.; height 0.50 mm.; width 0.50 mm. Male: length 0.88 mm.; height 0.52 mm.; width 0.45 mm. Variability: female: length 0.79–0.85 mm.; height 0.49–0.52 mm.

The range of this species as established in Trinidad is from the middle Eocene (Fitt Trace marl, *Globorotalia lehneri* zone) to the lower part of the upper Eocene (Hospital Hill marl, *Globigerapsis semiinvoluta* zone). In Cuba this species was reported from the lower Oligocene, but it has not been found in the Cipero formation of Trinidad. It remains to be seen, whether the actual stratigraphic range is longer, or it may be reworked in the Cuban Oligocene. It has also been found in the Chapapote, upper Eocene of Mexico.

Krithe cubensis van den Bold
Plate 3, figure 4a–b

Krithe cubensis VAN DEN BOLD, 1946, part, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 75, pl. 4, fig. 13b–d (not fig. 13a, see *K. elongata* n. sp.). – 1950, Jour. Pal., vol. 24, no. 1, p. 108 (part).

Re-examination of the types revealed the fact that different species have been included under *Krithe cubensis*. The species *K. cubensis* occurs with certainty only in the samples P 28, holotype (Finca Adelina, see Palmer and Bermudez, 1936), Tschopp sample 2393 (see van Bellen et. al., 1941) and in Bermudez samples 18, 36, 209 and 7 (see van den Bold, 1950, p. 108) making the range of *K. cubensis* upper Eocene to middle Oligocene. In the other samples from which the species was mentioned in 1946: Keyser sample 245 contains *Krithe trinidadensis* van den Bold, 1958, *Krithe hiwanneensis* Howe and Lea, and *Krithe elongata* n. sp. The age of this sample judging from the planktonic foraminifera determined by Keyzer (1945, p. 55) is lower Miocene and we would place it near the base of the *Globorotalia fohsi* zone, *sensu lato*.

Locality T1479, which contains the larger foraminifera *Heterostegina texana*, *Miogypsina* sp., and *Lepidocyclina giraudi* and the planktonic foraminifera *Globoquadrina altispira*, *Globigerina venezuelana*, *Globorotalia scitula* should be of roughly the same age. It contains the species *Krithe trinidadensis* van den Bold and *Krithe elongata* n. sp. This reduction of the stratigraphic range is in agreement with the range found in Trinidad which is from upper Eocene to lowermost Miocene.

Female: Ovate in side view, highest just posterior to the middle. Dorsal margin broadly arched with a slight sinuation in the anterior slope; anterior end broadly rounded, ventral margin slightly sinuate, posterior end projecting slightly beyond the regular curve of the posterior margin. Dorsal view spindle shaped, anterior end acute, posterior truncate and incised in the middle, greatest width in the middle.

Male: More elongate than the female, ventral margin less convex, dorsal margin more evenly arched.

Marginal area with anterior loop of line of concrescence, which shows eleven radial pore canals in the part parallel to the anterior margin; three false radial canals in the upper part of the loop, the middle one much longer than the others.

Dimensions: Male: length 0.79 mm.; height 0.42 mm.; width 0.38 mm.

The range of this species as established in Trinidad is from the upper Eocene (San Fernando formation, *Globorotalia cerroazulensis* zone) to lowermost Miocene (*Catapsydrax dissimilis* zone of the Cipero formation). In Cuba the species occurs in the upper Eocene, Oligocene and Oligo–Miocene. It was erroneously reported from the lower Eocene (Bermudez sample 20), van den Bold, 1950.

Krithe elongata van den Bold, **new species**
Plate 3, figure 5a–c

Krithe cubensis VAN DEN BOLD, 1946 (part), Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 75, pl. 4, fig. 13a.

Krithe sp. aff. *K. producta* Brady. – VAN DEN BOLD, 1958, Micropaleontology, vol. 4, no. 4, p. 398 (part, male), pl. 2, fig. 3b, f (not pl. 2, fig. 3a, c, d, see *Krithe morkhoveni* n. sp.).

Krithe trinidadensis VAN DEN BOLD, 1958 (part), *ibid.*, pl. 1, fig. 3g (not fig. 3a–f).

As has been pointed out under the preceding species *Krithe elongata* was included under *Krithe cubensis*. In van den Bold 1958, a drawing of the interior of the right valve of what was then supposed to be the male of *Krithe* sp. aff. *K. producta* Brady was shuffled with the figures for *Krithe trinidadensis*. In fact, plate 1, figure 3g should have read plate 2, figure 3g.

Carapace elongate, highest about the middle. Anterior end regularly rounded; dorsal outline convex in the left valve, slightly irregular in the right; posterior end very obliquely truncate, subventral; ventral outline slightly convex in the left valve, sinuate behind the middle in the right. Dorsal view elongate spindle-shaped, subacute in front, deeply incised behind, greatest width in the middle. Left valve overlapping the right along the dorsal margin and the posterior half of the ventral margin. Marginal area broad in anterior end with loop of the line of concrescence towards the outer margin, parallelling it from slightly above the middle to the ventral margin. In this area eleven radial pore canals occur, in the upper part of the loop there are five additional false radial canals, the one at the junction of line of concrescence and inner margin being much longer than the others. At the posterior end a similar but smaller loop occurs, which could not be observed accurately due to the thickness of the shell at the posteroventral angulation.

Dimensions: Length 0.76 mm.; height 0.37 mm.; width 0.32 mm.

The species is very similar in outline to *Krithe cancuenensis* van den Bold, but differs in being less angular, but slightly more truncate at the posterior end. The difference is not great and *K. cancuenensis* should be considered as a direct ancestor of *K. elongata*.

Krithe elongata has its first occurrence in the upper Eocene (Hospital Hill marl, Navet formation, *Globigerapsis semiinvoluta* zone). In the *Porticulosphaera mexicana* zone (Penitence Hill marl) and the *Truncorotaloides rohri* zone, neither *K. elongata* nor *K. cancuenensis* has been observed. The latest occurrence of *K. elongata* so far, has been in the middle Miocene (*Globorotalia menardii* zone, Lengua formation).

Holotype: A complete carapace from Wirz sample 214, *Globorotalia fohsi robusta* zone, upper Cipero formation, U.S.N.M. no. 563501; paratypes: U.S.N.M. no. 563502.

Krithe morkhoveni van den Bold, **new species**
Plate 3, figure 6

Krithe sp. aff. *producta* Brady. – VAN DEN BOLD, 1958, Micropaleontology, vol. 4, no. 4, p. 398 (part, female), pl. 2, fig. 3a, c, d (not 3b, f, see *Krithe elongata*).

Carapace ovate, highest just behind the middle, widest behind the middle. Anterior end evenly rounded; dorsal margin strongly arched in the left valve, sinuate anteriorly in the right valve; ventral outline regularly convex; margin slightly sinuate, almost straight in posterior part; posterior end very obliquely rounded to almost truncate, narrowly rounded ventrally; posterior margin steeply truncate. Dorsal view more or less ovate, subacute at anterior end, rounded and incised at the posterior end, widest behind the middle. Hingeline straight in the posterior two-third, separated from the dorsal outline in the left valve by a depressed area forming a kind of accomodation groove. Duplicature broad in anterior end. The loop of the line of concrescence has eleven radial pore canals in the part parallel to the anterior margin. In the upper part of the loop four false radial pore canals occur, the one near the junction of line of concrescence and inner margin being the longest. Posterior loop much smaller and showing only a few radial canals. Muscle scars: a posterior row of four, the upper one of which is slightly U-shaped, with a big cloverleaf shaped scar in front.

Dimensions: Length 0.68 mm.; height 0.41 mm.; width 0.39 mm.

Oldest occurrence of this species is in the *Catapsydrax stainforthi* zone of the Cipero formation. The latest occurrence observed is in the *Globorotalia menardii* zone of the Lengua formation. Range lower Miocene—?middle Miocene. The species has been named in honour of F.C.P.M. van Morkhoven, paleontologist with the Shell Oil Co, Lafayette, Louisiana.

Holotype: A complete carapace from Wirz sample 214, *Globorotalia fohsi robusta* zone, upper Cipero formation, U.S.N.M. no. 563506; paratypes: 563507.

Krithe hiwanneensis Howe and Lea

Krithe hiwanneensis Howe and Lea. – HOWE AND LAW, 1936, Louisiana Dept. Cons., Geol. Bull. 7, p. 72, pl. 5, figs. 32–34. – VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 76, pl. 4, fig. 20. – 1950, Jour. Pal., vol. 24, p. 108. – 1957, Micropaleontology, vol. 3, no. 3, p. 237.

Dimensions: Female: length 0.61–0.72 mm.; height 0.33–0.37 mm. Male: length 0.61–0.71 mm.; height 0.30–0.34 mm.

Range: Trinidad, from the middle of the upper Eocene (non-calcareous Mount Moriah silt, *Globorotalia cerroazulensis* zone) to the lower part of the Miocene (*Globorotalia fohsi barisanensis* zone). In the United States this species was also observed in the upper Jackson.

Genus PARAKRITHE van den Bold, 1958

Parakrithe vermunti (van den Bold)

Cytheridea (*Dolocytheridea*) *vermunti* VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 83, pl. 7, fig. 12a–c.

Parakrithe vermunti (van den Bold). – VAN DEN BOLD, 1958, Micropaleontology, vol. 4, no. 4, p. 399, pl. 4, fig. 7a–f.

The range of this species is lower Oligocene (upper part of the *Globigerina ampliapertura* zone, Calyx hole 57, 425–430 feet), to middle Miocene.

Parakrithe waitei van den Bold, **new species**
Plate 6, figure 5a–b

Carapace elongate ovate; anterior end evenly rounded; dorsal margin gently convex, ventral margin sinuate, concave in front of the middle; dorsal and ventral outline subparallel; posterior end obliquely rounded or obliquely truncate, narrowly rounded ventrally, dorsal slope only very slightly convex, nearly straight. Left valve overlapping the right along dorsal and ventral margins and the dorsal slope of the posterior end; greatest overlap anterodorsally; only a very slight overlap in the anterior end. Dorsal view lanceolate, widest just behind the middle; anterior end slightly compressed, posterior end rather blunt. Surface smooth. Normal pore canals few and widely scattered, open. Marginal area broad in the anterior end; line of concrescence forming a small, blunt-nosed loop in the direction of the outer margin; vestibule fairly large; radial pore canals eleven in anterior end with a few false radial ones.

Muscle scars: a posterior vertical row of 4 elongate scars with a V-shaped scar in front of the middle two above which is another rounded spot.

Dimensions: Holotype: length 0.50 mm.; height 0.26 mm; width 0. 23 mm.

The species is slightly shorter and wider than *Parakrithe vermunti* and the marginal area in the anterior end is different. The species is confined to the San Fernando formation. It is named in honour of S. T. Waite, former chief geologist of Shell Trinidad.

Holotype: A complete carapace from Harmony Hall well 2, 865 feet, San Fernando formation, upper Eocene; U.S.N.M. no. 563508; paratypes: U.S.N.M. no. 563509.

Parakrithe elongata van den Bold, **new species**
Plate 6, figure 6a–b

Carapace elongate, highest near the anterior end, which is evenly rounded, slightly projecting over dorsal and ventral margins. Dorsal margin straight, ventral margin sinuate, slightly concave anterior to the middle, subparallel; posterior end very obliquely truncate, angled ventrally, dorsal slope almost straight. Left valve overlapping the right along dorsal and ventral margin,

especially at both ends of the dorsal margin. Dorsal view elongate, lanceolate widest in front of the middle; anterior end compressed, posterior end blunt. Surface smooth, normal pore canals few and widely scattered, open.

Marginal area very similar to *Parakrithe vermunti*, line of concrescence and inner margin not coinciding in the anterior end; line of concrescence about parallel to the outer margin, vestibule sickle shaped; radial pore canals about 7 in number in anterior end with a few false radial ones, some bifurcating. Muscle scars: a posterior vertical row of four elongate scars; in front of the two middle ones a V-shaped scar above the posterior leg of which occurs another rounded scar.

Dimensions: Holotype: length 0.65 mm.; height 0.28 mm.; width 0.18 mm. This species is more elongate than the male of *Parakrithe vermunti*.

It has a range from middle Eocene (*Globigerapsis kugleri* zone) to lower Oligocene (*Globorotalia opima opima* zone).

Holotype: A complete carapace from Harmony Hall well 2, 865 feet, upper Eocene, San Fernando formation; U.S.N.M. no. 563513; paratypes: U.S.N.M. nos. 563514 to 563516.

Parakrithe? ovata van den Bold, **new species**
Plate 6, figure 7a–c

Carapace short, ovate, highest just behind the middle. Anterior end evenly rounded, dorsal margin convex, ventral margin slightly convex with a faint concavity in the middle; posterior end very steeply truncate, slightly angled or narrowly rounded ventrally; dorsal slope almost straight, very slightly convex. Left valve overlapping the right only very slightly along dorsal, posterior and midventral margin; strongest overlap anterodorsally. Dorsal view ovate, widest behind the middle,posterior end blunt, rounded; anterior end tapering, but not strongly compressed. Marginal area not observed. Muscle scars: a posterior vertical row of four elongate scars, the upper one of which is faintly U-shaped; in front of the two higher ones is a V-shaped scar with a single rounded scar just above the posterior leg of the V.

Dimensions: Holotype: length 0.43 mm.; height 0.28 mm.; width 0.23 mm.

The species cannot be assigned with certainty to *Parakrithe* as the marginal area was not observed. It is different in shape from *Parakrithe waitei*. It occurs in the San Fernando formation above the non-calcareous Mount Moriah silt.

A fairly similar species occurs in the Dunmore Hill and Friendship Quarry marls of the Navet formation. It differs by stronger convexity of the dorsal margin and stronger overlap of the left valve at the anterodorsal margin, which is slightly, but distinctly concave in the right valve. Only few specimens of this species have been found, and it is referred to as *Parakrithe*? sp., on the range chart (Chart 2) and the description of the type localities.

Holotype: A complete carapace from Renz sample 384, Vistabella marl, San Fernando formation, upper Eocene, U.S.N.M. no. 563510; paratypes: U.S.N.M. nos. 563511 and 563512

Subfamily Eucytherinae Puri
Genus Eucythere Brady, 1868

Eucythere sp.
Plate 6, figure 4

Carapace elongate triangular, highest about one third from the anterior end. Anterior end slightly obliquely rounded; dorsal margin angled at the greatest height and at about one fourth from behind, all three parts of the dorsal margin nearly straight, very slightly convex; ventral margin nearly straight, generally with a small concavity in the middle; posterior end very narrowly rounded, almost subacute, ventrally. Left valve overlapping the right slightly along most of the periphery, except in the anterior end and both ends of the ventral margin. Strongest overlap anterodorsally and midventrally. Dorsal view narrow, lanceolate, widest just anterior to the middle.

Dimensions: Length 0.55 mm.; height 0.28 mm.; width 0.10 mm.

The species is rather similar to *Eucythere triordinis* Schmidt (1948, p. 411 pl. 63, figs. 26, 27), also Munsey (1953, p. 15, pl. 3, fig. 6) and Key (1957, p. 88, pl. 2, fig. 13), but more elongate. It has been found only in Esmeralda well 1, 2630–2650 feet, "*Gaudryina* beds", lower or middle Eocene.

Subfamily Microtherinae Klie
Genus Microcythere G. W. Müller, 1894

Microcythere? sp.
Plate 6, figure 8

Carapace small, trapezoid in side view, slightly higher in front. Anterior end obliquely rounded, dorsal margin nearly straight, very slightly convex; ventral margin sinuate; posterior end obliquely rounded, slightly angled in the middle, narrowly rounded below the middle, dorsal slope almost straight, ventrally passing gradually into the ventral margin. Valves about equal in size, the right one may be overlapping very slightly along the dorsal margin. Dorsal view spindle-shaped, widest about the middle, ends compressed with slightly concave outline.

Muscle scars: A posterior vertical row of four scars, the middle two are rather elongate, with a small V-shaped scar in front.

Marginal area: Line of concrescence and inner margin widely separated in the anterior end, where the line of concrescence forms a loop towards the outer margin. Radial pore canals apparently few, some of them may be bifurcating. As only closed carapaces were found, no detailed study could be made of the marginal area and

nothing is known of the hinge. In fig. 8, the pore canals are shown to have the tendency to stand in groups of two. It is possible that this is caused by the fact that the drawing was made in transmitted light through both valves at the same time, so that one of the pair belongs to one valve and the other one to the other valve.

The shape approaches the species assigned to *Microcythere* in the American Tertiary, but is different from the species described by Muller, Klie and Hartmann from the Recent seas. The muscle scar is figured by Muller with one rounded spot in front of the posterior row, which is also different from the Trinidad species. The marginal area is very similar to the one figured by de Vos (1953, p. 25, figs. 4a–l, 5a–e) for *Redekea perpusilla* de Vos, while the shape is generally similar. However, only on this basis an assignment to this recent commensal ostracode genus seems highly questionable.

Dimensions: Length 0.43 mm.; height 0.25 mm.; width 0.19 mm.

This species has been found only in the upper Eocene San Fernando formation in Harmony Hall well 2, 686–804 feet, and Kugler sample 3741, Soldado Rock, bed no. 4 (*Globorotalia cerroazulensis* zone).

Subfamily LEPTOCYTHERINAE Hanai

Hanai (1957, p. 471) places the genus *Munseyella* in the Pectocytherinae, but I see no reason at present for separating Pectocytherinae and Leptocytherinae, one with three, the other with two genera. The difference in the marginal area to which Hanai points seems hardly a point for dividing the two, since simple and complicated marginal areas also occur in the Hemicytherinae.

Genus MUNSEYELLA van den Bold, 1957

Munseyella minuta (van den Bold)

Munseyella minuta (van den Bold). – VAN DEN BOLD, 1958, Micropaleontology, vol. 4, no. 4, p. 402, pl. 4, fig. 1a–e, pl. 5, fig. 2a–c.

This species has been found also in the upper Eocene from the Vistabella marl upward. Its range as visualized at present is from uppermost Eocene to middle Miocene.

Munseyella reticulata van den Bold, **new species**
Plate 7, figure 1a–d

Cytheromorpha sp. aff. *C. warneri* Howe and Spurgeon. – VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 3, p. 238, pl. 3, fig. 5a, b.

Carapace elongate subquadrate, highest at the anterior cardinal angle. Anterior end broadly rounded with a very small concavity just below the projecting anterior cardinal angle in the left valve; dorsal margin slightly convex; ventral margin somewhat sinuate in front of the middle, slightly converging posteriorly; posterior end subtruncate in the dorsal part, forming almost a right angle with the dorsal margin at the projecting posterior cardinal angle, rounded below. There is weak sexual dimorphism: males are more elongate and have a slightly more obliquely rounded anterior end. Surface reticulate, meshes more or less rounded and rather irregularly distributed with a tendency to be arranged in longitudinal rows in the ventral portion of the carapace. Anterior and posterior end are faintly rimmed. Just below and behind the anterior cardinal angle is a small eye spot. There is a faint subdorsal median sulcus.

Dimensions: Holotype, female: length 0.42 mm.; height 0.24 mm.; width 0.18 mm. Male: length 0.43 mm.; height 0.22 mm; width 0.17 mm.

The species is very similar in exterior characters to *Cytheromorpha warneri* Howe and Spurgeon (Howe and others, 1935, p. 11 pl. 2, figs. 5, 8, 9, pl. 4, fig. 4) although it is much shorter. The hinge and marginal area, however, are quite different and very similar to those described for *Munseyella*. In external characters the species is different from most species of *Munseyella* as this species does not possess the characteristic thickened rim along the periphery, so that it resembles in this respect *Pectocythere* Hanai (1957, p. 472), from which on the other hand it differs in many respects. The species has been found throughout the San Fernando formation and occurs also in the Mejias Quarry (lower Miocene *Catapsydrax dissimilis* zone).

Holotype: A complete carapace of a female from Kugler sample 3741, bed 4 of Kugler on Soldado Rock, U.S. N.M. no. 563517; paratypes: U.S.N.M. nos. 563518 to 563520.

Munseyella israelskyi Marianos and Valentine
Plate 7, figure 3

Munseyella israelskyi MARIANOS AND VALENTINE, 1958, Micropaleontology, vol. 4, no. 4, p. 366, pl. 2, fig. 6a–b, text-fig. 3.

Dimensions: Length 0.33 mm; height 0.18 mm.; width 0.16 mm.

This species occurs in the "*Gaudryina* beds" of Esmeralda well 1, 2630–3071 feet.

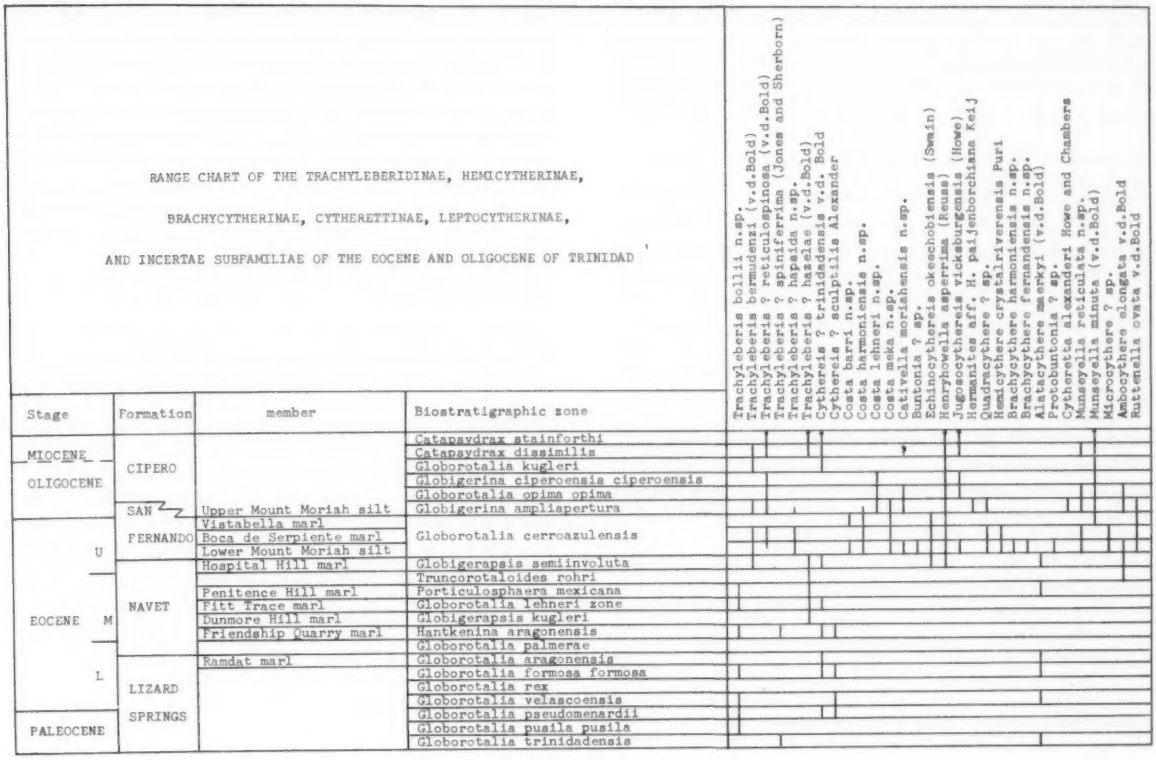
Munseyella sp.
Plate 7, figure 2

Shape very similar to *Munseyella minuta* (van den Bold). Ornamentation consists of a regular reticulate pattern in which two curved anterior ridges (same as in *M. minuta*) can be observed. Preservation does not allow a complete description, and the species is only figured to show the occurrence of this type of *Munseyella* in the "*Gaudryina* beds" of Esmeralda well 1, 3052–3071 feet.

Dimensions: Length 0.43 mm.; height 0.24 mm.; width 0.15 mm.

CHART 3

RANGE CHART OF TRACHYLEBERIDINAE, HEMICYTHERINAE, BRACHYCYTHERINAE, CYTHERETTINAE, LEPTOCYTHERINAE AND INCERTAE SUBFAMILIAE.



Subfamily TRACHYLEBERIDINAE Sylvester-Bradley
Genus TRACHYLEBERIS Brady, 1902

Trachyleberis bollii van den Bold, **new species**
Plate 4, figure 2a–b

Trachyleberis? sp., VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 1, p. 9, pl. 3, fig. 5a–b.

Carapace elongate ovate, spinose, highest at the anterior cardinal angle. Anterior end obliquely rounded in the left valve, almost evenly rounded in the right; dorsal margin straight, slightly depressed behind the projecting anterior cardinal angle in the left valve; ventral margin generally convex, slightly sinuate in front of the middle, converging slightly towards the dorsal margin posteriorly; posterior end laterally compressed, triangular, angled in the middle, straight above, convex below. The anterior end bears a triple row of blunt nodules, the outer row on the margin itself, the inner row shows as a heavy anterior rim broken up into about 10–12 heavy nodules, the middle row consists of nodules projecting forwards from the inner row, they are much larger in the ventral portion of the margin. The ventral part of the carapace also has three rows of spines, parallelling the ventral margin. Most of the spines are broad and often flattened on top with the tendency to bi- or trifurcate. A double row of small nodules fringes the entire posterior margin. A row of three very heavy spines flanks the dorsal margin, the spines projecting over it in side view. A cluster of small spines occurs at the subcentral swelling, behind it some groups of spines form an irregular longitudinal row, others are scattered over the surface of the valves. A prominent spine usually occurs at the anterior cardinal angle. The left valve is overlapping the right one clearly only at the anterior cardinal angle. In the anterior part of the carapace a few obscure remnants of a fine reticulation can be seen.

Dorsal view, widest behind the middle, irregularly spinose with heavy anterior rim and compressed posterior portion. Interior of the valves deep; in the muscle scar pit a posterior row of four scars can be seen, the second one from the top is divided into two separate scars, which is an unusual phenomenon in the Trachyleberidinae and much more common in the Hemicytherinae; in front is a single V-shaped scar.

Marginal area broad in the anterior end. Line of concrescence and inner margin coincide; radial pore canals numerous, slightly wavy and thickened towards the outer margin. Hinge in the right valve consists of a small anterior tooth, postjacent round socket and very faint groove in the dorsal margin; it could not be made out whether this groove is crenulate or not; at the posterior cardinal angle a large, blunt, ovate and oblique tooth occurs.

Dimensions: Holotype: length 0.73 mm.; height 0.42 mm.; width 0.32 mm.

Apart from the Paleocene and lower Eocene in which this species has previously been recorded, it occurs in the Penitence Hill and Fitt Trace marls and Friendship Quarry marls of the Navet formation. In the upper Eocene it is replaced by the much larger *Trachyleberis bermudezi*. The species has been named after H. M. Bolli, in recognition of his valuable stratigraphic work on the planktonic foraminifera of Trinidad.

Holotype: A complete carapace from Renz sample 385, Penitence Hill marl, Navet formation, U.S.N.M. no. 563521; paratypes: U.S.N.M. nos. 563522 and 563523.

Trachyleberis bermudezi (van den Bold)
Plate 4, figure 1; plate 8, figure 1

Cythereis bermudezi VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 99, pl. 10, fig. 18a, b.

Cythereis spinosa Lienenklaus. – VAN DEN BOLD, 1946, ibid., p. 90, pl. 10, fig. 10 (moult).

Not *Cythereis spinosa* LIENENKLAUS, 1900, Zeitschr. d. Deutsche Geol. Gesell., p. 516, pl. 20, fig. 4.

Cythereis montgomeryensis Howe and Chambers. – VAN DEN BOLD, 1950, Jour. Pal., vol. 24, no. 1, p. 108.

Not *Cythereis montgomeryensis* HOWE AND CHAMBERS, 1935, Louisiana Dept. of Cons., Geol. Bull. no. 5, p. 37, pl. 1, figs. 13, 16; pl. 2, figs. 22, 23; pl. 6, figs. 19, 20.

Both description and figure of this species as given by the writer in 1946 are very poor and are insufficient for recognizing the species. *Cythereis spinosa* as figured in 1946, probably represents a young moult of this species. In 1950 this was considered to represent a moult stage of *Cythereis rosefieldensis* Howe and Law, but it is much more probable that it belongs to *Trachyleberis bermudezi* instead. Carapace elongate subquadrate, highest at the anterior cardinal angle, where the left valve overlaps the right conspicuously. Anterior end almost evenly rounded, spinose, and bearing a flat spinose rim; dorsal margin straight, obscured in side view by some of the spines of the dorsal ridge; ventral margin convex, fringed with small flattened spines; posterior end bluntly angled in the middle, strongly spinose. The ornamentation consists of several rows of spines with others scattered over the surface. Many of the spines are either flattened on top or exhibit small secondary spines near the top. Usually they are quite heavy. Most conspicuous is a group of spines forming the subcentral tubercle; behind that, separated from it by a rather deep depression is a median row of five spines. Another row of four spines parallels the dorsal margin, while a longer ventral row of eight spines shows the size of the spines increasing towards the posterior end of the row. Below this ventral row is a narrow sharp, denticulate ventral ridge. Other spines occur between dorsal and median row and in front of the subcentral group and especially between median and ventral row. The dorsal view is spinose and very irregular. Interior of the valves deep. Marginal area broad, crossed by numerous, thin, long, pore canals. Line of concrescence and inner margin coincide. Hinge and muscle scar are typical for the genus.

Dimensions: Length 1.21 mm.; height 0.70 mm.

Cythereis montgomeryensis Howe and Chambers differs by its oblique anterior end, which has a heavier and higher rim and also in details of the spinose ornamentation.

The species seems to be very close to *Trachyleberis tridens* Hornibrook (1952, p. 33, pl. 3, figs. 42, 43, 49), which has, however, higher spines on the subcentral tubercle while the median row of spines is less pronounced; also the spines at the anterior cardinal angle are longer.

In Cuba the species occurs in the upper Eocene and lower Oligocene. In Trinidad it has been found in the upper Eocene, Oligocene and lowermost Miocene (*Catapsydrax dissimilis* zone). San Fernando formation localities are Calyx well 57, 830–840 feet, Stainforth samples 153 and 244A, Kugler sample 3692 (Soldado Rock) and Kugler sample 8829 from Hospital Hill marl.

Trachyleberis? spiniferrima (Jones and Sherborn)

Trachyleberis? spinosissima (Jones and Sherborn). – VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 1, p. 9, pl. 3, fig. 4a–b.

This species has been found in the Friendship Quarry marl and in the "*Gaudryina* beds". *Pterygocythereis mucronata* (Sars) was described by Brady in 1865 under the name *Cythereis spinosissima* and not *Cythere spinosissima* as erroneously claimed in the synonymy of this species (van den Bold, 1957). Therefore the name *spinosissima* is preoccupied for *Cythereis*.

Trachyleberis? reticulospinosa (van den Bold)

Cythereis reticulospinosa VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 100, pl. 6, fig. 18.

Trachyleberis reticulospinosa (van den Bold). – VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 3, p. 241, pl. 1, fig. 10.

This species occurs in the San Fernando formation, the lowest stratigraphic occurrence is in Calyx well 59 at 480 feet. It also occurs in the Boca de Serpiente marl on Soldado rock. Range: upper Eocene — lower Miocene.

Trachyleberis? hapsida van den Bold, **new species**
Plate 4, figure 3a–b

Carapace elongate, highest at the anterior cardinal angle, widest about one third of the length from the posterior end. Anterior end slightly obliquely rounded, bearing a row of anteriorly projecting spines, 4 to 5 small ones above the middle, 3 to 4 larger ones with flattened base, almost nipple shaped, below the middle and 5 to 6 small ones in the ventral part. The anterior margin is parallelled by a row of laterally projecting spines, ending dorsally in the anterior cardinal angle, which is pronounced, especially in the left valve. Dorsal margin straight, slightly depressed between the projecting cardinal angles in the left valve; ventral margin sinuate, converging posteriorly; posterior end sharply produced, laterally compressed, angled in the middle, concave above, convex and bearing 4 to 5 spines below. Posterior cardinal angle in the left valve projecting. Left valve overlapping the right at both cardinal angles and in the dorsal part of the posterior end. Surface reticulate, provided with a strong ventral ridge in which the ridges of the reticulation project to form spines, the posterior one of which is much larger than the others and it is here that the greatest width occurs. Close to the ventral margin is a short, sharp, parallel ridge. A similar ridge parallels the dorsal margin, flattening the dorsal portion of the carapace. In the anteroventral portion of the carapace some of the reticulations exhibit spines projecting into the meshes. There is a faint, curved depression in the centre of the valves, suggesting the presence of a subcentral tubercle.

Dimensions: Length 0.79 mm.; height 0.43 mm.; width 0.35 mm.

This species is related to both *Trachyleberis? spiniferrima* and *reticulospinosa*. A closely similar species occurs in the upper Eocene Pauji formation of the Maracaibo basin. Another undescribed related species occurs in the Jackson upper Eocene of the Gulf Coast. It is quite possible that this group of species which seems to be intermediate between *Trachyleberis* and *Costa*, belongs to an undescribed genus.

The species occurs throughout the San Fernando formation, as high as the upper Mount Moriah silt. The name is derived from *hapsis* (Gr.), net or mesh.

Holotype: A complete carapace from Kugler sample 3692, Soldado Rock, U.S.N.M. no. 563524; paratypes: U.S.N.M. no. 563525.

Trachyleberis? hazelae (van den Bold)

Trachyleberis? hazelae (van den Bold). – VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 3, p. 241, pl. 1, fig. 11.

The range of this species has been established from middle Eocene to middle Miocene. Lowest occurrence in the Dunmore Hill marl, *Globigerapsis kugleri* zone.

Genus CYTHEREIS Jones, 1849

Cythereis? trinidadensis van den Bold

Cythereis? trinidadensis VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 1, p. 8, pl. 3, fig. 1a–d.

As reported before, the range of this species is Upper Cretaceous to middle Miocene. It occurs scattered throughout the Navet formation.

Cythereis? sculptilis Alexander

Cythereis? sculptilis Alexander. – VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 1, p. 8, pl. 3, fig. 2a–b.

Highest occurrence of this species is in the Friendship Quarry marl.

Genus COSTA Neviani, 1928

Costa barri van den Bold, **new species**
Plate 4, figure 4a–b

Carapace subrectangular, highest about one-fourth from the anterior end at the anterior cardinal angle. Anterior end broadly and somewhat obliquely rounded, very finely denticulate, rimmed; dorsal margin depressed behind the anterior cardinal angle in the left valve, straight, converging posteriorly towards the ventral margin, which is nearly straight with a small concavity anterior to the middle; posterior end strongly compressed laterally, triangular in side view, concave above the middle, convex and bearing four rather large spines below.

Valves reticulate and ornamented with three longitudinal ridges and an anterior rim. Anterior rim parallel to anterior margin with a small eye-tubercle at the dorsal end. Transverse ridges project anteriorly of the rim, especially in the lower half of the valve. Dorsal ridge rising behind a small depressed area, posterior to the eye-tubercle, straight, obscuring the dorsal margin in the posterior two-thirds and terminating just in front of the posterior cardinal angle. Just anterior to the center of the valve lies a subcentral tubercle which is ill-defined in its anterior portion; from its dorsal part extends a median ridge parallel to the dorsal one, ending vertically below the posterior end of the dorsal ridge, just in front of the compressed posterior triangle.

Ventral ridge actually consisting of two ridges, starting as one in the second ridge of the reticulation behind the anterior rim and becoming divided into two just below the subcentral tubercle. The upper one parallels the ventral margin, the lower one converges towards it, reaching it just at its posterior end, vertically below the ends of dorsal and median ridge. These two ventral ridges form a narrow, oblique, meshed surface in the middle third of the carapace. The surface between the ridges is coarsely reticulate, the reticulations spreading out from the subcentral tubercle. The shape of the meshes is characteristic in the posterior part of the area between dorsal and median ridge, where they form

interlocking Vs. In dorsal view the posterior end is much more strongly compressed than the heavily rimmed anterior end. The two median ridges converge slightly towards the posterior, the ventral ridges diverge slightly and are only visible in their posterior third, being obscured by the median ridges and the subcentral tubercles in the anterior part. Dorsal ridges nearly parallel, diverging very slightly posteriorly. The greatest width occurs at the posterior end of the ventral ridges, but is only very slightly more than the width at the subcentral tubercle, so that the sides of the carapace give the impression of being parallel.

Dimensions: Holotype: length 0.78 mm.; height 0.43 mm.; width 0.36 mm.

Sexual dimorphism is present but only very slightly. The species has been named in honour of K. W. Barr, chief geologist of Texaco Trinidad, Inc.

The species has been found in Barr's samples 7244 and 7244a–c, St. Joseph village, San Fernando and in two zones of Harmony Hall well 2, 828–840 feet and 1988–2000 feet, also in the non-calcareous Mount Moriah silt and the Vistabella marl.

Holotype: A complete carapace from Barr sample 7244, U.S.N.M. no. 563526; paratypes: U.S.N.M. no. 563527.

Costa lehneri van den Bold, **new species**
Plate 4, figure 5a–b, plate 8, figure 4a–b

Carapace more or less pyriform in side view, highest near the anterior end at the anterior cardinal angle, which projects strongly in the left valve.

Anterior end broadly rounded, finely denticulate in the upper half, slightly more coarsely so in the lower half, bearing a denticulate rim; dorsal margin straight, in the left valve depressed between the two projecting cardinal angles; ventral margin sinuate, in general slightly convex downward but with a small concavity just in front of the middle; posterior end short, bluntly angled in the middle, lower part rounded and bearing a double row of small blunt spines, upper part straight, laterally compressed. Surface reticulate, irregular, with small nodes on some of the ridges.

Three longitudinal ridges can be recognized, but all are rather ill-defined and irregular. Dorsal ridge, slightly higher in front than behind, curving down anteriorly towards the median ridge; some of the ridges of the reticulation form projecting spines above the dorsal margin. Median ridge in general parallel to the dorsal one and converging towards the ventral ridge, slightly angled in the center and curving slightly downward in the anterior part. Ventral ridge convex downward, parallel to the ventral margin, sometimes rather obscure in the middle portion of the valve. The denticulate anterior rim continues parallel to the ventral margin below the ventral ridge. Between the ridges the valves are reticulate. The arrangement of the meshes between dorsal and median ridge is characteristic. One large group of meshes is formed between the down-curving dorsal ridge and the downwardly deflected anterior part of the median ridge; behind this are three parallel cross ridges, perpendicular to both median and dorsal ridge and at the end of the shorter median ridge a large inverse V-shaped mesh occurs which is divided into secondary meshes by cross ridges.

Muscle scar: a vertical row of four scars, the third and especially the second from above being much more elongate, lying at the posterior side of a shallow pit; on the anterior side of the pit occurs a single V-shaped scar, horizontally in front of the two topmost scars of the posterior row. Marginal area broad in anterior end. Line of concrescence and inner margin coincide; radial pore canals very numerous, long, slightly sinuous, slender and apparently all simple. They are slightly widened near the anterior margin. Hinge in the right valve consists of an anterior knoblike tooth, placed on a broader, flat base, a small but deep, round socket and a narrow, straight, smooth groove; posterior tooth large, blunt, slightly lobate. In the left valve rounded terminal sockets and an intermediate smooth bar with a small rounded tooth at the anterior end.

Dimensions: Holotype: length 0.83 mm.; height 0.53mm.; width 0.37 mm.

The species has been named after Dr. E. Lehner in recognition of his contributions to Trinidad geology. It occurs in the Oligocene, its highest occurrence being in the *Globigerina ciperoensis ciperoensis* zone, its lowest occurrence in the non-calcareous Mount Moriah silt (*Globorotalia cerroazulensis* zone).

There is slight sexual dimorphism; the females have a variation in length from 0.75–0.88 mm. and from 0.48–0.55 mm. in height, while the males vary from 0.84–0.88 mm. in length and 0.50–0.53 mm. in width.

Holotype: A complete carapace from Calyx hole 57, 250–260 feet, U.S.N.M. no. 563528; paratypes: U.S.N.M. no. 563529.

Costa harmoniensis van den Bold, **new species**
Plate 4, figure 6a–b

Carapace elongate subrectangular, reticulate, spinose in parts, highest about one fourth from the anterior end at the anterior cardinal angle. Anterior end broadly rounded, denticulate and with denticulate rim, which continues as a low flat ridge parallel to the ventral margin; ventral margin somewhat sinuate, dorsal margin straight, slightly depressed behind the anterior cardinal angle in the left valve, converging very slightly towards the ventral margin; posterior end short, angled about the middle, straight or slightly concave above, rounded and denticulate below.

Ventral ridge rather obscure, sometimes only consisting of a row of knoblike spines, such as are scattered all over the carapace in well preserved specimens. It is convex downward. Dorsal ridge equally obscure, consisting of

the pointed or spinose tops of the reticulations, only locally obscuring the dorsal margin. Median ridge occupying the exact median line in the posterior portion of the carapace in front of the compressed posterior triangle. It diverges slightly from dorsal and ventral margins anteriorly; just in front of the center it divides into two branches, the upper one continuing in the same general direction, but concave upwards, the lower one parallelling the upper one at a distance of one mesh. Just behind and below the posterior end of the second ridge is a slight depression of the muscle scar pit. The male is relatively longer and narrower and dorsal and ventral margin are converging more strongly posteriorly. The median ridge is about parallel to the ventral margin and converges towards the dorsal margin posteriorly. Dorsal view with compressed ends, the posterior one much more strongly than the anterior; greatest width about one third from the posterior end.

Dimensions: Holotype, female: length 0.86 mm.; height 0.50 mm.; width 0.42 mm.; male: length 0.89 mm.; height 0.50 mm.; width 0.39 mm. Variability; female: length 0.79–0.86 mm.; height 0.46–0.50 mm; male: length 0.81–0.89 mm.; height 0.46–0.50 mm.

This species appears to be related to *Costa lehneri* n. sp., the main difference being the direction of the median ridge. It occurs in the upper Eocene and lowermost Oligocene, its highest known occurrence is in Calyx hole 57, 910–920 feet, *Globigerina ampliapertura* zone. A fairly similar species occurs in the "*Gaudryina* beds" of Esmeralda well 1 which will not be described because of insufficient material.

Holotype: A complete carapace from Calyx well 57, 910–920 feet, U.S.N.M. no. 563530; paratypes U.S.N.M. nos. 563531 to 563534.

Costa meka van den Bold, **new species**
Plate 4, figure 7a–b

Carapace elongate, quadrangular, highest about one-fifth from anterior end at the anterior cardinal angle. Anterior end obliquely rounded with four to six coarse teeth in the lower half and smaller denticules in the upper, bearing a strong smooth ridge with a glassy eye-tubercle near the upper end. In the lower part, this ridge bears scalloped, rounded, nodules and it continues as a smooth ridge along, very close to and almost parallel to, the ventral margin. Dorsal margin straight, depressed behind the anterior cardinal angle, converging posteriorly slightly to the ventral margin, which is gently sinuate, almost straight; posterior end laterally compressed, triangular in side view, angled in the middle, slightly concave above, rounded below and with a raised rim which bears a few blunt spines in the lower part.

The carapace is reticulate with a fairly regular pattern and ornamented with three longitudinal ridges: dorsal ridge lobate, slightly convex, just obscuring part of the dorsal margin; ventral ridge shorter, often ill-defined in the middle or near its posterior end; median ridge very long, horizontal, slightly above the middle, splitting off a lower branch which runs obliquely forward and downward from just in front of the middle. The main ridge converges slightly towards the posterior end of the dorsal one. Dorsal view with compressed ends, of which the posterior one is more strongly compressed; sides almost parallel; width at the median ridge just in front of the middle almost equal to the greatest width at the posterior end of the ventral ridge. The two ventral ridges diverge posteriorly in dorsal view while the median ridges converge slightly. Males are more slender than the females and possess a stronger concavity at the junction of ventral and posterior margins.

Hinge and marginal area are similar to *Costa lehneri*, except for a widening of the median groove of the hinge in the right valve near the posterior tooth.

Dimensions: Holotype, female: length 0.79 mm.; height 0.42 mm.; width 0.37 mm; male: length 0.79 mm.; height 0.37 mm.; width 0.30 mm.

The name is derived from the Greek *mekos* meaning length. The species may be related to *Isocythereis?* aff. *fissicostis* Triebel (van den Bold, 1957*a*, p. 9, pl. 3, fig. 3a, b). It occurs scattered in the San Fernando formation, but is nowhere common.

Holotype: A female carapace from Harmony Hall well 2, 1988–2000 feet, U.S.N.M. no. 563535; paratypes: U.S.N.M. nos. 563536 to 563538.

Genus CATIVELLA Coryell and Fields, 1937

Cativella moriahensis van den Bold, **new species**
Plate 4, figure 8; plate 8, figure 5

?Cativella sp. cf. *semitranslucens* (Crouch). – VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 3, p. 243, pl. 2, fig. 6.
Not *Cativella* aff. *semitranslucens* (Crouch). – VAN DEN BOLD, 1958, Micropaleontology, vol. 4, no. 4, p. 404, pl. 3, fig. 3.

Carapace elongate, quadrangular, highest about one-fourth from the anterior end at the anterior cardinal angle below which lies a glassy eye-tubercle.

Anterior end obliquely rounded, bearing three large spines in the ventral half and up to nine small ones above and below these; dorsal margin depressed between the two prominent cardinal angles, straight, converging posteriorly towards the ventral margin, which is nearly straight, with a small concavity anterior to the middle; posterior end laterally compressed, triangular, angled in or slightly below the middle, concave above, convex and bearing a double row of spines below. The inner row of spines projects laterally, the outer row is only slightly deflected laterally.

Ornamentation consists of very high, longitudinal crests and a reticulation. The ridges of the reticulation support the crests and the shell of the crests between these

ridges is very thin and in cases even perforated. Anterior ridge, very obliquely curved, more strongly than the anterior margin and continuing dorsally a short distance beyond the eye-tubercle, and ventrally parallel to the ventral margin, obscuring it as far as the posterior end. A thin, slightly alate ventral ridge, running obliquely down from just behind the anterior ridge towards the ventral margin, curves upward near its posterior end and terminates in a strong spine. A long median ridge extends from near the anterior ridge till inside the posterior triangle. It is slightly convex upward. A dorsal ridge starts from just behind the eye-tubercle and is convex upward, obscuring the dorsal margin completely and joining it in front of the posterior cardinal angle. Between the ridges the valves exhibit a reticulate pattern, standing at right angles to the longitudinal crests. Locally small tubercles are raised from the junctions of the ridges of the reticulation. The inside of the valves shows a fairly deep subcentral pit, which is not visible on the outside. At the posterior side of the pit is a vertical row of four muscle scars; the second one from the top is much longer than the others. In front of this scar and at the anterior side of the pit lies a small V-shaped scar with the sharp end of the V pointing forward.

Marginal area broad in anterior end, slightly less in posterior. Line of concrescence and inner margin coincide; radial pore canals numerous, straight, slightly widened near the middle. Hinge in the right valve consists of a strong anterior tooth, a postadjacent rounded socket, which opens into a straight groove and a posterior, blunt, knoblike tooth. In the left valve a bar with a small knoblike tooth at its anterior end lies between terminal rounded sockets.

This species shows a variation in the thickness of the shell. The specimens from Stainforth sample 47 are all very thin and fragile, on the other hand similar specimens from Harmony Hall well 2, 1894–1906 feet, and the Paloma Alta formation of Venezuela are much more robust. The same holds true for the specimen from the Mejias Quarry which has been questionably referred to this species. In Rohr sample 25684, type locality for the *Globorotalia cerroazulensis* zone, both thefragile and the robust types occur. Another peculiarity is that there seem to be two sizes of adults: two male carapaces from Stainforth sample 47 are much larger than an apparently adult female.

Dimensions: Holotype, large male: length 0.74 mm.; height 0.42 mm. Adult female, Harmony Hall well no. 2: length 0.60 mm.; height 0.35 mm.; female, Harmony Hall well no. 2: length 0.75 mm.; height 0.42 mm.; female, Paloma Alta,: length 0.75 mm.; height 0.39 mm. The measurements are taken from margin to margin and do not include the spines.

Holotype: A left valve from Stainforth sample 47, *Globigerina ampliapertura* zone, Point Bontour. U.S.N.M. no. 563539; paratypes: U.S.N.M. no. 563540.

Genus BUNTONIA, Howe 1935

Buntonia alabamensis (Howe and Pyeatt)

Buntonia alabamensis (Howe and Pyeatt). – VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 1, p. 8.

This species has only been found in the "*Gaudryina* beds" of the Nariva Cocal well 1 of Shell Trinidad and in T.P.D.'s Esmeralda well 1 and in the Paleocene of Shell Trinidad's well FC-98 and T.T.C.'s Rochard well 1, also in samples from the Marac Quarry. It does not occur in the Navet and Lizard Springs formations, the deeper water facies of which was apparently unfavorable to the development of this species.

Buntonia seminuda (Stephenson)

Pyricythereis seminuda STEPHENSON, 1944, Jour. Pal., vol. 18, no. 5, p. 453, pl. 76, fig. 5, 6. – VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 103.

This species occurs in Trinidad only in the "*Gaudryina* beds".

Buntonia? sp.

Plate 5, figure 2a–b; plate 8, figure 11a–b

Carapace elongate triangular, highest about one third from the anterior end. Anterior end broadly rounded, continuing with regular curve into dorsal and ventral margin in the left valve, slightly obliquely rounded in the right and forming an obtuse angle with the dorsal margin; dorsal outline sinuate in the left valve, regularly but gently convex in the anterior two third, concave and curving upward to the produced posterior cardinal angle in the posterior part, straight in the right valve; ventral margin regularly convex with a slight concavity in the middle; ventral and dorsal margin converging posteriorly; posterior end angled about the middle, slightly concave above, forming a continuation of the ventral margin below and bearing a few small denticles in the right valve. Left valve overlapping the right along the periphery; greatest amount of overlap anterodorsally.

Dorsal view elongate, spindle-shaped, ends compressed, greatest width just behind the middle in the ventral portion of the carapace. Valves sometimes finely striate with faint longitudinal ridges, more pronounced and convex downward in the ventral portion, about horizontal in the center; the ridges become fainter towards dorsal and anterior margins. Many specimens appear to be entirely smooth, in others the ribs show only in the posterior half of the carapace. A small but distinct eye-spot occurs just below the greatest height. Muscle scars: a posterior row of four, with a small V-shaped scar in front.

Marginal area moderately broad; line of concrescence and inner margin coincide; radial pore canals very numerous, straight, simple, often standing in groups of two or three. Hinge in the right valve: a high knob-like tooth standing on a flattened, oblique, curved base, a postjacent small rounded socket, opening into a

straight crenulate groove; posterior tooth large, outwardly deflected, subtriangular in dorsal view, faintly carved. Hinge in the left valve is complementary to the one in the right. Sexual dimorphism pronounced: males are longer and slenderer than females and their posterior end is much narrower.

Dimensions: Female: length 0.74 mm.; height 0.45 mm.; width 0.35 mm.; male: length 0.80 mm.; height 0.45 mm.; width 0.35 mm.

Only few specimens of this species have been found in the San Fernando formation, Calyx well 59, 440–450 feet, Barr sample 7244. It is much more common in the upper Eocene Pauji formation of the Maracaibo basin.

The following genera are usually assigned to the Trachyleberidinae, but in some of the characters they appear to be intermediate between these and the Hemicytherinae. As the characters of these subfamilies have not been described in detail by their authors it is left undecided here to which subfamily they belong.

Genus **Henryhowella** Puri, 1957

Howella Puri, 1956, Jour. Pal., vol. 30, no. 2, pp. 274, 275, not *Howella* Ogilby, 1899.

Type species: Cythere evax Ulrich and Bassler, 1904 p. 119, pl. 36, figs. 6–8.

The description of the genus as given by Puri has to be amended in the following ways: radial pore canals long and sinuous, often joined together at the base or branching, especially in the lower half of the anterior margin. Hinge in the right valve with blunt, fairly elongate, very slightly lobate anterior tooth (plate 8, fig. 3), which in side view is comma-shaped; the median groove is finely crenulate, posterior tooth blunt, knoblike.

The material on which this description is based comes from Dr. Howe's collection of material from Plum Point, Maryland, at about 18 feet above the base of the cliff. It was compared to *Henryhowella asperrima* (Reuss) from Baden, one of Reuss' original localities. In general the European species seems to be somewhat more finely built than the American one. Hinge and marginal area are practically identical. The species from Trinidad figured as *Henryhowella asperrima* (Reuss) is so similar to both *Henryhowella evax* and the European species that it does not seem to serve any practical purpose to try and separate them. The inside of the right valve as figured is identical to both of them.

Howella echinata Puri (1956, p. 275, pl. 35, figs. 9–14) as identified by the present writer from the Cooper marl is very similar in exterior to the other forms, but in the single specimen where the marginal area could be studied in transmitted light, the radial pore canals are slightly more simply built although some of them are seen to be branching. It should be pointed out, however, that the name *Henryhowella echinata* is preoccupied by *Henryhowella asperrima echinata* (Reuss).

Henryhowella asperrima (Reuss)
Plate 4, figure 10, plate 8, figure 2

Henryhowella asperrima (Reuss). – van den Bold, 1957, Micropaleontology, vol. 3, no. 3, p. 242, 243 (with synonymy).

This species has been observed throughout the upper Eocene in both San Fernando and Hospital Hill formation; it also occurs in all stages of the Oligocene. A fairly similar, undescribed species, occurs in the middle Eocene, but preservation does not allow a description, hence it has been referred to, in the list of the faunas of the type localities, as *Henryhowella* sp.

Dimensions: Female: length 0.70–0.82 mm.; height 0.44–0.52 mm.; male: length 0.73–0.84 mm.; height 0.43–0.48 mm.

Genus Echinocythereis Puri, 1954

Echinocythereis okeechobiensis (Swain)
Plate 4, figure 9

Cythereis? okeechobiensis Swain, 1946, Jour. Pal., vol. 20, p. 378' pl. 54, fig. 10a–b, pl. 55, fig. 3a–b.

Echinocythereis okeechobiensis (Swain). – Puri, 1954, Florida Geol. Surv., Bull. 36, p. 260. – Puri, 1957, Florida Geol. Surv., Bull. 38, p. 196, pl. 8, fig. 7–10, pl. 9, figs. 1–4.

This species occurs in the upper Eocene of the Hospital Hill marl (Navet formation) and in the San Fernando formation.

Genus Jugosocythereis Puri, 1957

This genus is accepted here provisionally, but it is pointed out, that no distinct separation has been made from genera like *Quadracythere* or *Hermanites*, and that the muscle scar pattern as described by Puri (1957, p. 200) is totally inconsistent with the Trachyleberidinae. Moreover, some of the species described by Puri under this genus do not seem to belong here.

Jugosocythereis vicksburgensis (Howe)

Cythereis vicksburgensis Howe. – Howe and Law, 1956, Louisiana Dept. of Cons., Geol. Bull. 7, p. 34, pl. 4, fig. 4, pl. 5, fig. 1–2.

Cythereis vicksburgensis Howe. – van den Bold, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 69, pl. 10, fig. 5. – van den Bold, 1950, Jour. Pal., vol. 24, no. 1, p. 82.

Cythereis bicarinata Swain, 1946, Jour. Pal., vol. 20, p. 376, pl. 54, fig. 7a–d, pl. 55, fig. 1a–e.

Hermanites? pannosa (Brady). – van den Bold, 1957, Micropaleontology, vol. 3, no. 3, p. 240, pl. 2, fig. 2.

Jugosocythereis bicarinata (Swain). – Puri, 1957, Florida Geol. Surv., Bull. 38, p. 200, pl. 12, figs. 11–20.

The writer compared this species with *Cythere pannosa* Brady (1869, *Fonds de la Mer*, p. 154, pl. 19, fig. 1–2), but now doubts that the species are really identical. Therefore, it seems better to give it the name under which it was first described in detail. In Trinidad the

species occurs in the Oligo—Miocene (St. Croix, Mejias, Kapur, Morne Diablo and Quinam quarries), ranging from the *Globorotalia opima opima* zone to the *Globorotalia mayeri* zone, and in a few samples from the San Fernando formation (upper Eocene).

Genus Hermanites Puri, 1955

Hermanites sp. aff. **Hermanites paijenborchiana** Keij
Plate 8, figure 10

Hermanites paijenborchiana Keij, 1957, Inst. Roy. Sci. Belgique, Mém. 136, p. 110, pl. 17, figs. 11–14, pl. 21, figs. 10–11.

The Trinidad species differs from *Hermanites paijenborchiana* Keij, in having a longer ventral ridge and the tendency of two of the radiating anterior ridges to become raised. From *Hermanites haidingeri* (Reuss) and *Hermanites tschoppi* (van den Bold) it differs by a lesser development of the dorsal ridge and a slightly more irregular arrangement of the anterior reticulation.

This species has been found in Stainforth sample 47, *Globigerina ampliapertura* zone, Point Bontour. After a comparison of specimens of *Cypridina haidingeri* Reuss, *Cythereis tschoppi* van den Bold and *Hermania reticulata* Puri, I have come to the conclusion that the last two species are identical. They differ from *Hermanites haidingeri* in their general coarser appearance: the subcentral tubercle is thicker, but not higher, the ribs of the reticulation are heavier and the alae are slightly blunter. There is, however, no doubt about it that they are very closely related. The species referred to as *Hermanites haidingeri* (Reuss), (van den Bold, 1957*b*, p. 239, pl. 2, fig. 1a–b) should be known as *Hermanites tschoppi* (van den Bold).

Hermanites? sp.
Plate 8, figure 7

A few complete pyritized specimens which could possibly be referred to *Hermanites* have been found in the "*Gaudryina* beds" of Esmeralda well 1. One is figured merely to illustrate its occurrence.

Genus Quadracythere Hornibrook, 1952

Quadracythere? sp.
Plate 8, figure 8

Carapace subquadrate, highest very near the anterior end, which is very broadly and slightly obliquely rounded. Dorsal outline slightly irregular, ventral outline sinuate, converging gently posteriorly; posterior end short, rounded and irregularly nodular below the middle, concave above. Ventral part of the anterior margin very finely denticulate. Left valve overlapping strongly at both cardinal angles. Ornamentation with an irregular pattern of ridges among which the dorsal and ventral ridge stand out. Ventral ridge parallel to the ventral margin, consisting of two parallel ridges behind the middle; dorsal ridge starting slightly above and in front of the ventrally placed subcentral node, which is also irregular in outline. This ridge forms almost a hemicircle and is nodular in the upper part, where it obscures the dorsal margin; it ends in a kind of node just below and in front of the posterior cardinal angle. A weaker ridge connects the node with the posterior end of the ventral ridge. Behind this ridge the carapace is strongly compressed.

Dimensions: Length 0.69 mm.; height 0.42 mm.

Several species of *Quadracythere?* occur as single carapaces in the upper Eocene San Fernando formation. They are generally similar to undescribed species occurring in the upper Jackson of the Gulf Coast, but are not identical. One of these specimens has been selected for illustration because it is well preserved and shows a more complicated pattern of ridges than most of the others.

Genus Ambocythere van den Bold, 1958

Ambocythere elongata van den Bold
Plate 8, figure 6

Hemicythere? stolonifera (Brady). – van den Bold, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 102 (part).

Not *Cythere stolonifera* Brady, 1880, Challenger Report.

Hemicythere stolonifera (Brady). – van den Bold, 1950, Jour. Pal., vol. 24, no. 1, p. 108 (part).

Ambocythere elongata van den Bold, 1958, Ann. Mag. Nat. Hist., ser. 12, vol. 10, p. 811, figs. 9, 10.

This species, which was originally found in the upper Eocene and possible lower Oligocene of Cuba, occurs in Trinidad in four places: Calyx well 57, 258–260 feet, *Globorotalia opima opima zone*, lower Oligocene; Harmony Hall well 2, 494–852 feet; non-calcareous Mount Moriah silt and Mount Moriah boulder bed?, *Globorotalia cerroazulensis* zone, San Fernando formation and Kugler sample 8829, *Globigerapsis semiinvoluta* zone of the Navet formation, upper Eocene; and Esmeralda well 1, 300–394 feet, *Truncorotaloides rohri* zone, uppermost Middle Eocene. A few specimens of an undescribed species of *Ambocythere* have been found in the *Truncorotaloides rohri* and the *Globorotalia lehneri* zones of the Navet formation, middle Eocene. Their poor preservation makes a thorough description impossible, but their presence is mentioned here because they mark the oldest occurrence of this genus so far.

Genus Occultocythereis Howe, 1952

Occultocythereis? sp.
Plate 8, figure 9

Carapace elongate, subquadrate, highest at anterior cardinal angle. Anterior end obliquely rounded, dorsal margin almost straight, ventral margin concave, almost parallel; posterior end slightly angled in the middle, almost obliquely rounded. The anterior end is heavily rimmed, the rim terminating dorsally in an eye-tubercle, just below the anterior cardinal angle. Ventral ridge

short, occupying the middle third of the carapace. Just above the anterior end of the ventral ridge an elongate, oblique swelling represents the subcentral tubercle.

Dimensions: Length 0.62 mm.; height 0.30 mm.

Only a few specimens have been found in the "*Gaudryina* beds" of the Esmeralda well 1. Because of strong pyritisation no internal structures can be described.

Subfamily HEMICYTHERINAE Puri
Genus HEMICYTHERE Sars, 1925

Hemicythere crystalriverensis Puri

Hemicythere crystalriverensis PURI, 1957, Florida Geol. Surv., Bull. 38, p. 202, pl. 13, figs. 21–24.

The species has been found at one locality of the San Fernando formation only: Kugler sample 3741, Bed 4 of Kugler on Soldado Rock.

Subfamily CYTHERETTINAE Triebel
Genus CYTHERETTA G. W. Muller, 1894

Cytheretta alexanderi Howe and Chambers

Cytheretta alexanderi HOWE AND CHAMBERS, 1935, Louisiana Dept. Cons., Geol. Bull. 5, p. 45, pl. 5, figs. 17–21, pl. 6, figs. 27, 28. – MONSOUR, 1937, Am. Assoc. Petr. Geol., Bull. no. 21, p. 95, table 1. – BERGQUIST, 1943, Miss. Geol. Surv., Bull. 49, p. 109, pl. 11, fig. 20. – BLAKE, 1950, Jour. Pal., vol. 24, p. 177, pl. 30, figs. 1–3. – PURI, 1952, Jour. Pal., vol. 26, p. 208, pl. 39, fig. 16. – SWAIN, 1952, U.S. Geol. Surv., Prof. Paper, 234-A, p. 47, pl. 6, figs. 23–25. – WILBERT, 1953, Arkansas Div. of Geol., Bull. 19, p. 125, pl. 1, fig. 15. – PURI, 1957, Florida Geol. Surv., Bull. 38, p. 195, pl. 7, figs. 1–4.

Only one complete carapace, which fits exactly the description of this species has been found in Calyx hole 59, 320–330 feet, *Globigerina ampliapertura* zone.

Subfamily BRACHYCYTHERINAE Puri
Genus BRACHYCYTHERE Alexander, 1933

Brachycythere? harmoniensis van den Bold, **new species**
Plate 2, figure 5a–b

Carapace ovate, highest in front of the middle, widest behind the middle.

Female: Anterior end broadly and slightly obliquely rounded, denticulate in the lower half; anterior cardinal angle prominent in the right valve, obscure in left; dorsal margin slightly convex, nearly straight in both valves; ventral outline convex, margin slightly sinuate, converging towards the dorsal margin posteriorly; posterior end angled about the middle, straight above, convex below, bearing a few small blunt spines. Left valve overlapping the right along the entire periphery, strongest overlap along ventral and dorsal margin and in the dorsal part of the anterior and posterior margins. Surface of the valves finely pitted, almost smooth near the periphery. Small but distinct eye spot below anterior cardinal angle. Ventral portion of the carapace swollen in the middle, but never to such an extent that it obscures the ventral outline in side view. Dorsal view spindle-shaped, ends compressed, greatest width at about one third from the posterior end.

Sexual dimorphism pronounced; male similar in general aspect to the female, but more slender and dorsal and ventral margin converge more strongly posteriorly, so that the posterior end in the male is lower. Marginal area moderately broad in anterior end, line of concrescence and inner margin coincide; radial pore canals numerous, sinuous, slightly thickened in anterior third, sometimes branching. Hinge in the right valve consists of an anterior tooth, which has a long anterior slope rising from the selvage; an adjacent round socket and crenulate groove. Unfortunately in the material at hand the posterior tooth could not be observed.

Dimensions: Holotype, female: length 0.94 mm.; height 0.59 mm.; width 0.46 mm. Male: length 0.91 mm.; height 0.52 mm.; width 0.43 mm. Variability: female, length 0.92–1.06 mm.; height 0.58–0.67 mm.; male, length 0.92–1.06 mm.; height 0.52–0.53 mm.

This species and the following one were found in a zone of reworked material, containing *Cytherella guasarensis* van den Bold and *Cytherella kellettae* (Munsey). However, it also occurs in the type sample of the *Globorotalia cerroazulensis* zone (Rohr sample 25684) in which no reworked ostracodes have been found. The species is believed to belong to the fauna of the San Fernando formation, but apparently only occurs in the basal portion.

Holotype: A complete carapace of a female from Harmony Hall well 2, core 828–840 feet, U.S.N.M. no. 563541; paratypes: U.S.N.M. no. 563542.

Brachycythere fernandensis van den Bold, **new species**
Plate 2, figure 6a–b

Carapace pyriform-triangular, highest in front of the middle behind the anterior cardinal angle, widest just behind the middle. Anterior end broadly rounded, slightly oblique, finely denticulate in lower two-third; dorsal margin in the left valve very slightly convex, straight in the right; ventral margin convex in left valve, sinuate in the right, strongly converging posteriorly; posterior end bluntly angled below the middle, slightly concave above, convex below. Left valve overlapping the right strongly on dorsal and ventral side and the dorsal part of anterior and posterior margin. Dorsal view spindle-shaped, ends compressed.

Surface of the valves almost smooth, very finely pitted. Small eye spot just below the anterior cardinal angle. Ventral portion of the carapace swollen, obscuring the middle of the ventral margin in the right valve only. Sexual dimorphism pronounced, males more slender and more drawn out posteriorly.

Dimensions: Holotype; female: length 0.81 mm.; height 0.49 mm.; width 0.43 mm.; male: length 0.86 mm.; height 0.48 mm.; width 0.43 mm. Variability: female: length 0.79–0.84 mm.; height 0.47–0.51 mm.; male: length 0.78–0.89 mm.; height 0.47–0.51 mm.

This species was originally thought identical with *Brachycythere? kugleri soldadensis* van den Bold (1957*a*, p. 11), but the length-height ratios are different and the anterior end is longer in the upper Eocene species. Also the features of overlap in *Brachycythere? kugleri* and subspecies are different, since the left valve does not overlap at the posterior cardinal angle in the Paleocene material. Also this species occurs (like the preceding) in a zone of reworked material from the Paleocene (*Cytherella guasarensis* and *Cytherella kellettae*).

Holotype: A complete female carapace from Barr sample 7244, St. Joseph village, San Fernando, San Fernando formation, U.S.N.M. no. 563543; paratypes: U.S.N.M. no. 563544.

Genus Alatacythere Murray and Hussey, 1942

Alatacythere maerkyi (van den Bold)

Brachycythere maerkyi van den Bold, 1957, Micropaleontology, vol. 3, no. 1, p. 10, pl. 3, fig. 8a, b.

This species has been found in the Penitence Hill marl and Hospital Hill marl of the Navet formation and ranges from Paleocene to lower upper Eocene.

Genus Protobuntonia Grekoff, 1953

Protobuntonia? sp.
Plate 2, figure 7

Carapace triangular-ovate, highest in front of the middle. Anterior end slightly obliquely rounded; dorsal margin slightly convex with in the left valve a small concavity in front of the projecting anterior cardinal angle; ventral margin convex in the left valve, slightly sinuate in the right; posterior end angled just above the middle, convex below, almost straight above. Left valve overlapping the right strongly along the ventral margin, less at the cardinal angles, no appreciable overlap elsewhere. Dorsal view lanceolate, widest in front of the middle, slightly compressed near the anterior end, posterior end gradually tapering. There is a small eye spot just below the anterior cardinal angle. Surface finely but deeply pitted. Only closed carapaces occurred and the interior could not be studied.

Dimensions: Length 0.79 mm.; height 0.47 mm.; width 0.34 mm. Variability: length 0.75–0.82 mm.; height 0.44–0.48 mm.

This species is very similar in outline and shape to the male of *Protobuntonia numidica* Grekoff (1953, p. 400, text-fig. 1a–f) from the Upper Cretaceous of Algeria. The species has been found only in the San Fernando formation in Harmony Hall well 2, 828–840 feet, in the same zone of reworking as *Brachycythere harmoniensis* n. sp. It is conceivable that it has been derived from older deposits.

Genus Bosquetina Keij, 1957

Bosquetina? concepcionensis van den Bold, **new species**
Plate 5, figure 3a–b

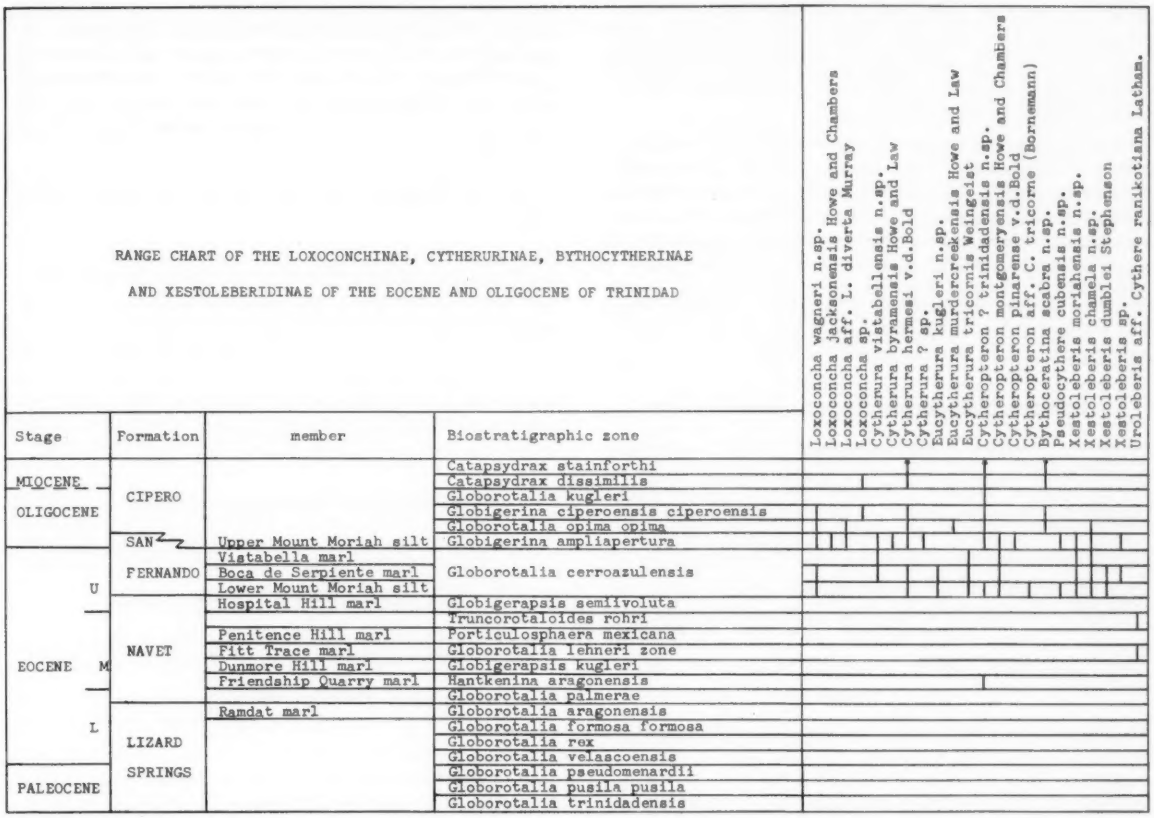
Carapace pyriform, highest at the anterior cardinal angle, widest just behind the middle. Anterior end broadly rounded, faintly rimmed and finely denticulate; dorsal margin slightly depressed behind the anterior cardinal angle in the left valve, slightly convex in both valves, more strongly so in the left and converging towards the ventral margin which is almost straight, slightly sinuate; posterior end short, laterally compressed, bluntly angled in the middle, convex below, straight above in the left valve, slightly concave in the right. Left valve overlapping the right along the dorsal part of the anterior margin, anterior and posterior cardinal angles, the dorsal margin and the dorsal part of the posterior margin. Dorsal view ovate, ends slightly compressed. Surface finely punctate to very delicately reticulate, deepest punctations in the middle, near the ventral side, shallower and larger towards the center and from there onward towards the dorsal, anterior and posterior margins the punctations become more and more insignificant until the surface is almost smooth near the posterior margin. There is a faint ventral ridge parallelling the ventral margin and partly obscuring it. It is not visible in dorsal view since it is obscured by the swollen central portion of the carapace. Just below the anterior cardinal angle is a small eye tubercle with a faint oblique groove just behind it. Slight sexual dimorphism occurs: males are more slender than females and have an almost straight dorsal margin in the left valve. The hinge could only be studied in part: it consists in the left valve of a round anterior socket, followed by a smooth bar which is slightly raised at its anterior end, but does not form a distinct tooth. Marginal area fairly broad in anterior end, no vestibule observed. Pore canals numerous, a number of them pierce the outer lamella before reaching the outer margin.

Dimensions: Holotype, length 0.61 mm.; height 0.36 mm.; width 0.32 mm.

The species occurs in Trinidad only in the "*Gaudryina* beds" of the subsurface, probably lower or middle Eocene in age. It is common in the Concepcion formation of the Maracaibo Basin where the stratigraphic range is from lower Eocene to middle Eocene. The species has been questionably assigned to *Bosquetina* with which genus it has the following characteristics in common: hinge without a strong anterior tooth in the left valve; marginal area with numerous radial pore canals, part of them false, slightly sinuous and sometimes branching; general shape; weak ornamentation. It differs in having only a very weak ventral ridge which

CHART 4

RANGE CHART OF LOXOCONCHINAE, CYTHERURINAE AND XESTOLEBERIDINAE.



does not terminate posteriorly in a strong spine. Moreover, it is much smaller than the species assigned by Keij to *Bosquetina*.

It is named after the Concepcion formation of Maracaibo, in which it occurs in much greater numbers than in Trinidad.

Holotype: A complete carapace of a female from Esmeralda well 1, core 2630–2650 feet, U.S.N.M. no. 563545; paratypes: U.S.N.M. no. 563546.

Subfamily LOXOCONCHINAE Sars
Genus LOXOCONCHA Sars, 1866

Loxoconcha wagneri van den Bold, **new species**
Plate 7, figure 4a–b

Carapace subquadrate. Anterior end broadly and somewhat obliquely rounded, often slightly angular just above the middle; dorsal and ventral margin almost straight and parallel; posterior end pointed or narrowly rounded in the middle, the dorsal side convex, forming an angle of about 120° with the dorsal margin at the posterior cardinal angle, and almost perpendicular to the convex ventral part. Anterior cardinal angle in the left valve slightly produced, overlapping the right valve; other areas of overlap are the ventral margin and the ventral part of the posterior end. Dorsal view spindle-shaped, swollen, widest in the middle, ends very strongly compressed, sharp. Mid-ventral portion of the carapace swollen, but not overhanging, the ventral margin bordered ventrally by a few faint ridges. Valves reticulate or deeply punctate, the punctations forming concentric rows in the ventral part, no definite pattern discernable in the dorsal part. There is a small eye-spot at the anterior cardinal angle. Just in front of the posterior cardinal angle is a short, low, convex dorsal ridge which just obscures part of the dorsal margin.

Dimensions: Holotype, female, length 0.47 mm.; height 0.29 mm.; width 0.27 mm. Variability: female, length 0.47–0.55 mm.; height 0.27–0.33 mm.; male, length 0.47–0.56 mm.; height 0.26–0.31 mm.

In the male the dorsal and ventral margins converge very slightly posteriorly.

The species is close to *Loxoconcha claibornensis* Murray (1938, p. 588, pl. 68, figs. 2, 19) but the dorsal view, as can be seen in *Pyricythereis delicata* Sutton and Williams (1939, pl. 64, figs. 5–7), has much less strongly compressed ends. *Loxoconcha delemontensis* Oertli (1956, p. 68, pl. 8, figs. 211–219) differs in the shape of the posterior end and does not possess the small dorsal ridge. Moreover, it is somewhat smaller.

This species has been named in honour of Dr.C. Wagner, paleontologist with N.V. de Bataafsche Petroleum Maatschappy, The Hague, Holland. It has been found in most of the localities of the San Fernando formation and appears to range upward to the *Globigerina ciperoensis ciperoensis* zone of the Oligoene Cipero formation.

Holotype: A complete carapace from Kugler sample 3741, Bed 4 of Kugler on Soldado Rock, U.S.N.M. no. 563547; paratypes: U.S.N.M. nos. 563548–563551.

Loxoconcha jacksonensis Howe and Chambers

Loxoconcha jacksonensis Howe and Chambers, 1935, Louisiana Dept. Cons., Geol. Bull. 5, p. 41, pl. 4, fig. 20, pl. 5, fig. 14, pl. 6, figs. 8, 9. – Monsour, 1937, Am. Assoc. Petr. Geol., Bull. no. 21, table 1. – Bergquist, 1942, Mississipi Geol. Surv., Bull. no. 49, p. 109, pl. 11, fig. 18. – Wilbert, 1953, Arkansas, Div. of Geol., Bull. 19, p. 125.

This species has been found in abundance only in Stainforth sample 47, *Globigerina ampliapertura* zone.

Loxoconcha sp. aff. **Loxoconcha diverta** Murray
Plate 7, figure 5

This species is rather similar to *Loxoconcha chamfera* var. *diverta* Murray (1938, p. 592, pl. 68, figs. 11, 12) in respect to the reticulate pattern and the long posterior end, but differs in having a much less pronounced dorsal ridge. It has been found only in the lower Oligocene.

Loxoconcha sp.
Plate 7, figure 6a–c

Carapace small, ovate, walnut-shaped, pointed behind, highest in the middle. Anterior end obliquely rounded, a small concavity within the right valve just below the anterior cardinal angle; dorsal outline convex, hinge margin straight; ventral margin sinuate in front of the middle; posterior end fairly sharply pointed above the middle, concave above, convex below. Tumid portion of the carapace overhanging part of the ventral margin. Valves reticulate with rounded meshes and strongly raised ridges which produce a sponge-like appearance. The lower rows visible in side view are parallel to the strongly curved rim of the overhanging, tumid portion of the carapace, the lower row of meshes splitting off a second one in the anterior part. In the centre the alignment is indistinct and in the dorsal part roughly parallel to the dorsal outline. In the anterior portion some meshes are joined to form longitudinally elongate excavations which seem to spread out fan-like from the middle of the anterior margin. Dorsal view widest in the middle, walnut-shaped with short but sharply drawnout ends. Hinge consists in the right valve of a median crenulate groove; at its anterior end it widens and curves around a small tooth situated on the low bar separating the groove from the interior of the valve; at the posterior end this bar forms a curved elongate tooth, curving around a small open socket. The shell is very thick and heavy and consequently the pore canals could only be seen very indistinctly in transmitted light. Therefore no description of the marginal area is given.

Dimensions: Length 0.45 mm.; height 0.32 mm.; width 0.30 mm.

The shape is reminiscent of *Loxoconcha subovata* (Münster), compare Oertli (1956, p. 69, pl. 8, figs. 220–223); but this species lacks the peculiar alignment of the meshes in the anterior end. A species which appears to show this has been figured as *Loxoconcha* sp. *A*, by Brown (1958, p. 66, pl. 6, fig. 8) from the upper Castle Hayne limestone, ?upper Eocene of North Carolina. Only two specimens of this very distinct species have been found, one in the Oligocene, one in the lowermost Miocene.

Loxoconcha claibornensis Murray

Loxoconcha claibornensis Murray, 1938, Jour. Pal., vol. 12, p. 588, pl. 68, figs. 2, 19. – Stephenson, 1946, Jour. Pal., vol. 20, p. 315, pl. 43, fig. 13.
Pyricythereis delicata Sutton and Williams, 1939, Jour. Pal., vol. 13, p. 568, pl. 64, figs. 5–7.
Loxoconcha delicata (Sutton and Williams). – Stephenson, 1944, Jour. Pal., vol. 18, p. 454, pl. 76, fig. 10.
Loxoconcha sp. aff. *L. claibornensis* Murray. – Swain, 1951, U.S. Geol. Surv., Prof. Paper 234–A, p. 26, pl. 2, figs. 16, 17.

This species has the shape and the sharply angled posterior end of *Loxoconcha claibornensis*, but differs in having a sharper angle between the ventral and lateral surfaces. At present this difference does not seem sufficient to distinguish the two forms. It has only been found in the "*Gaudryina* beds".

Subfamily Cytherurinae G. W. Müller
Genus Cytherura Sars, 1866

Cytherura vistabellensis van den Bold, **new species**
Plate 7, figure 7a–b

Carapace elongate, subquadrate, higher posteriorly and swollen posterodorsally. Anterior end obliquely rounded; dorsal margin straight; ventral margin sinuate, curving upwards posteriorly; dorsal and ventral margin converging slightly anteriorly; posterior end a subdorsal caudal process, the upper margin forming a convex continuation of the dorsal margin, lower margin concave. Dorsal view more or less elongate hexagonal, lateral outlines almost parallel, ends pointed and compressed with concave lateral outlines. Posterodorsal part swollen; in front of this swelling, about in the middle of the valves lies a deep rounded sulcus, divided into a dorsal and ventral part by an obliquely longitudinal ridge, which becomes obscure in front of the centre. In

the posteroventral portion there is another rounded sulcus, bordered on the dorsal side by a horizontal, longitudinal ridge which extends from the anterior margin to the compressed posterior end; on the ventral side it is bordered by a short ventral ridge which forms the ventral side of the tumid portion of the carapace. Anterior to the second sulcus is another longitudinal ridge, parallel to the upper one and divided into two parallel ridges near the anterior margin.

Dimensions: Holotype: length 0.34 mm.; height 0.20 mm.; width 0.17 mm. Largest specimen: length 0.45 mm.; height 0.25 mm.; smallest specimen: length 0.32 mm.; height 0.20 mm.

Cytherura sp. *B* (Brown, 1958, p. 59, pl. 7, fig. 7) from the upper Castle Hayne limestone in North Carolina appears to be rather similar in also possessing a posteroventral depressed area.

The species is rare and has been found at Stainforth 47 (*Globigerina ampliapertura* zone) Point Bontour, Kugler sample 3962 (Boca de Serpiente marl, Soldado Rock) and Renz sample 384 (Vistabella marl).

Holotype: A complete carapace from Stainforth sample 47, U.S.N.M. no. 563552; paratypes: U.S.N.M. nos. 563553 and 563554.

Cytherura byramensis Howe and Law

Cytherura byramensis Howe and Law, 1936, Louisiana, Dept. Cons., Geol. Bull. 7, p. 69, pl. 6, fig. 3.

The species has only been found at Stainforth 47, *Globigerina ampliapertura* zone.

Cytherura hermesi van den Bold

Cytherura hermesi van den Bold, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 117, pl. 14, fig. 15a–b. – 1957, Micropaleontology, vol. 3, no. 3, p. 245, pl. 4, fig. 10a–b.

This is the most common species of *Cytherura* in the Trinidad Tertiary. It has a range from upper Eocene to middle Miocene. In the present material it has been found in the lower Oligocene of Calyx well 57, and the upper Eocene of Soldado Rock, Kugler sample 3741.

Cytherura sp.
Plate 7, figure 8a–b

Carapace elongate, subquadrate. Anterior end vertically truncate in the middle part, rounded above and below; dorsal margin very slightly convex, ventral margin slightly sinuate, parallel; posterior end forming a blunt caudal process, just above the middle, concave dorsally and ventrally. Ornamentation: a short ventral ridge, parallel to the ventral margin and forming the edge of the flattened ventral surface; it curves sharpely towards the ventral margin slightly behind the middle, thus reducing the ventral surface by half. Below the middle there is a long horizontal, longitudinal ridge, convex downward, starting very near to the anterior margin and becoming slightly irregular at its posterior end. Near the anterior end it gives off a branch which is convex upward and irregular and which is shorter than the main ridge and ends diagonally below the posterior cardinal angle, against the posterior leg of an inverted Y which is formed by a system of smaller ribs. The vertical branch of this inverted Y is very short and terminates against the thickened dorsal margin. Ends abruptly compressed in dorsal view; greatest width in the posterior half of the lower longitudinal ridge. Hinge in the right valve consists of a broad and deep groove in the dorsal margin below the ends of which occur two short, faintly cusped terminal teeth. Above this groove is a narrow bar separating it from the dorsal margin. Marginal area broad in both ends, line of concrescence and inner margin coincide except in the anterior end where they lie at a short distance. Pore canals few, sinuous, often not quite reaching the outer margin. Seven or eight in the anterior end. Muscle scar a vertical posterior row of four with a group of three in front.

Dimensions: Length 0.40 mm.; height 0.20 mm.; width 0.13 mm. (single valve)

Only one right valve of this very typical and easily recognizable species has been found in Stainforth sample 47, *Globigerina ampliapertura* zone. The species has been described in some detail because the hinge does not seem to fit completely the description given by Wagner (1957, p. 74, pl. 33) for the genotype.

Genus Eucytherura G. W. Müller, 1894

Eucytherura kugleri van den Bold, **new species**
Plate 7, figure 9a–b

Carapace small, subquadrate. Anterior end very broadly and obliquely rounded; dorsal outline gently convex with the dorsal margin sunk in between two rather ill-defined ridges, which form the flattened dorsal portion of the carapace, straight with a small concavity in front of the projecting posterior cardinal angle; ventral margin slightly sinuate, slightly converging posteriorly towards the dorsal margin, obscured by a ventral ridge in most of its length; posterior end short, obtusely angled above the middle, straight above and below. Left valve overlapping the right at both cardinal angles and the dorsal part of the anterior end.

Carapace coarsely reticulate, the reticulations starting from a point lying below and in front of the centre of the valve. A strong ventral ridge slopes obliquely down from near the anterior margin until it obscures the ventral margin, after that it parallels more or less the dorsal outline. Above this ridge, from just in front of the middle backward, there is a second ridge which projects laterally over the ventral one, especially in the anterior part. The posterior portion of the carapace is rather strongly swollen, the posterior end is very strongly compressed behind a line running from just in front of the posterior cardinal angle obliquely downward to the posterior end

of the two ventral ridges. In front of the second ventral ridge the carapace shows a longitudinal depression lying above the ventral ridge; another depressed area occurs just above the second ridge in the posterior half of the carapace. A few of the ridges of the reticulation are more pronounced in some of the specimens than in others; they run vertically down from the dorsal outline. The anterior one, which lies just behind the anterior cardinal angle is usually the best developed.

Dorsal view, short and wide; anterior end bluntly angled and slightly irregular because of the anterior ridge mentioned above. Greatest width at the anterior end of the second ventral ridge. Above it the carapace is slightly compressed, but widens gently posteriorly until it is abruptly and strongly compressed just in front of the posterior cardinal angle.

Dimensions: Holotype: length 0.34 mm.; height 0.18 mm.; width 0.20 mm.

Of all species of *Eucytherura* described, *Eucytherura hiwanneenis* Weingeist (1949, p. 374, pl. 73, fig. 10) seems most similar to our species, but it shows so many points of difference, that it is certainly not identical. The species is named for H. G. Kugler of Texaco Trinidad Inc. It is fairly common in some samples from the San Fernando formation (Kugler samples 3741, 3692, Boca de Serpiente marl, Rohr sample 25684, *Globorotalia cerroazulensis* zone).

Holotype: A complete carapace from Kugler sample 3741, U.S.N.M. no. 563555; paratypes: U.S.N.M. no. 562556.

Eucytherura murdercreekensis Howe and Law

Eucytherura murdercreekensis Howe and Law, 1936, Louisiana, Dept. Cons., Geol. Bull. 7, p. 71, pl. 4, fig. 31; pl. 5, fig. 26. – Weingeist, 1949, Jour. Pal., vol. 23, no. 1, p. 7, pl. 73, fig. 16.

This species has only been found in Calyx well 57, 310–320 feet and elsewhere in the *Globorotalia opima opima* zone of the Oligocene.

Eucytherura tricornis Weingeist

Eucytherura tricornis Weingeist, 1949, Jour. Pal., vol. 23, no. 1, p. 378, pl. 73, fig. 20.

This species is locally fairly common in the San Fernando formation (Kugler sample 3741, bed 4 on Soldado Rock, Renz sample 384, Vistabella marl and Harmony Hall well 2, 712–721 feet.)

Eucytherura sp.
Plate 7, figure 10

Carapace small, subquadrangular, highest at the anterior cardinal angle. Anterior end obliquely and very broadly rounded, forming above a pronounced anterior cardinal angle in the left valve; dorsal margin sinuate, depressed in the posterior half; ventral margin sinuate in front of the middle, generally convex, continuing into the lower part of the subdorsally angled posterior end; the upper part of the posterior end is straight and forms an obtuse angle with the dorsal margin. Left valve overlapping the right conspicuously only at the posterior cardinal angle. Valves faintly reticulate with an irregular pattern. Ventral portion of the carapace swollen and obscuring the ventral margin in its posterior part; anterior swelling just in front of the middle and subventrally, slightly more pronounced than a posterior swelling just behind the middle. Between the two swellings there is a faint subventral sulcus. An obscure dorsal ridge parallels the dorsal margin in its posterior half, ending at the posterior cardinal angle, behind which the carapace is strongly compressed. Greatest width at the anterior swelling.

Dimensions: Length 0.26 mm.; height 0.17 mm.

The species occurs occasionally in the "*Gaudryina* beds", figured specimen is from Esmeralda well 1, 2630–2650 feet.

Genus Cytheropteron Sars, 1866

Cytheropteron? trinidadensis van den Bold, **new species**
Plate 5, figure 5a–c

Carapace pyriform, alate, with subventral caudal process, highest and widest in the middle. Anterior end obliquely rounded, more narrowly rounded subventrally, slightly more evenly rounded in the right valve than in the left; dorsal margin arched in the left valve, nearly straight in the right; ventral margin slightly sinuate just behind the anterior end, convex in the posterior part; posterior end narrowly rounded or slightly angled subventrally, dorsal part concave, more strongly so in the right valve than in the left. Left valve overlapping the right strongly along the dorsal margin. Dorsal view regularly ovate, ventral portion of the valves in the female strongly swollen in the middle; near the ends the ala projects more strongly beyond this tumid portion. Near the ends the valves are strongly compressed; the anterior end is shorter than the posterior. In the male the ala is more visible in dorsal view because the ventral part of the carapace above it is less swollen than in the female. In side view the ala obscures the greater part of the ventral margin; it possesses a thick flattened rim. Between the ala and the ventral margin lies a longitudinal ridge on the ventral surface. Surface of the valves minutely pitted.

Muscle scars: A vertical row of four, the second from the top lying slightly more backward; four more scars form an upwardly deviating, oblique row in front of the two upper scars of the posterior row. Of these the topmost, second and fourth are parallel, while the third stands at almost right angles to the others. Normal pore canals, about 20 in each valve, widely spaced and large, apparently open. Marginal area fairly broad in both ends; line of concrescence and inner margin coincide; radial pore canals few, simple, straight and widely spaced, often not reaching the outer margin; about 9 in anterior end. The selvage lies close and parallel to the outer margin in the left valve, rather far inside in the right.

Hinge: In the right valve terminal cusped teeth with four cusps in the anterior one and five in the posterior; a shallow, straight, crenulate groove in between lies below the dorsal margin. In the left valve there are terminal, crenulate sockets and a shallow, finely crenulate, median bar. Above this bar is a deep accommodation groove.

Dimensions: Holotype, female: length 0.72 mm.; height 0.50 mm.; width 0.42 mm. Male: length 0.68 mm.; height 0.45 mm; width 0.39 mm.

The shape of this species is strongly reminiscent of young instars of *Brachycythere russelli* Howe and Lea (for synonymy see Stephenson, 1946, p. 333; *Digmocythere russelli* (Howe and Lea) in Mandelstam, 1958, p. 277), but the wide marginal area and well developed radial pore canals show this species to be an adult form. Its shape and strongly overlapping dorsal margin are so different from normal *Cytheropteron* species that it can be assigned only questionably to this genus, and it may prove to belong to an, as yet, undescribed genus. The species appears to be long ranging. It is very common in the middle Miocene Lengua formation, fewer specimens have been found in the middle and upper Eocene and the lower Oligocene.

Holotype: A complete carapace of a female from Barr sample 7689, U.S.N.M. no. 563557; paratypes: U.S.N.M. nos. 563558 to 563562.

Cytheropteron montgomeryensis Howe and Chambers

Cytheropteron montgomeryensis HOWE AND CHAMBERS, 1935, Louisiana Dept. Cons., Geol. Bull. 5, p. 19, pl. 3, figs. 14–16, pl. 4, figs. 11, 12, 16. – MONSOUR, 1937, Am. Assoc. Petr. Geol., Bull. no. 21, table 1. – VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 114, pl. 2, fig. 12. – BERGQUIST, 1942, Mississippi, Geol. Surv., Bull. 49, p. 106, pl. 11, fig. 6. – VAN DEN BOLD, 1950, Jour. Pal., vol. 24, no. 1, p. 108. – WILBERT, 1953, Arkansas, Div. Geol., Bull. 19, p. 125.

This species appears to be confined to the upper part of the San Fernando formation (uppermost Eocene and lowermost Oligocene).

Cytheropteron pinarense van den Bold

Cytheropteron pinarense VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 113, pl. 16, fig. 2a, b.

Only one specimen has been found in Calyx well 59, 460–470 feet, San Fernando(?) formation, *Globigerina ampliapertura* zone. In Cuba it is also confined to the lower Oligocene.

Cytheropteron sp. aff. **Cytheropteron tricorne** (Bornemann)
Plate 5, figure 6a–b

?*Cythere tricorne* Bornemann, 1855, Deutsch. Geol. Ges., Zeitschr., vol. 7, pt. 2, p. 367, pl. 21, fig. 8.

?*Cytheropteron tricorne* (Bornemann). – LIENENKLAUS, 1900, Deutsch. Geol. Ges., Zeitschr., vol. 52, p. 541, pl. 22, fig. 2.

Cytheropteron tricorne (Bornemann). – VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 114, pl. 16, fig. 3a–b.

The anterior end of the Cuban and Trinidad specimens is less angular than the figures of Lienenklaus and Bornemann indicate. The specimens from Trinidad are slightly more punctate than the Cuban ones, but otherwise quite similar. The species has been found only in the upper Eocene of the San Fernando formation at Barr sample 7244a and b. The Cuban specimens came from the lower Oligocene.

Subfamily BYTHOCYTHERINAE Sars
Genus BYTHOCERATINA Hornibrook, 1952

Bythoceratina scabra van den Bold, **new species**
Plate 5, figure 4a–b

Bythoceratina sp. aff. *Bythoceratina scaberrima* (Brady). – VAN DEN BOLD, 1957, Micropaleontology, vol. 3, no. 3, p. 246, pl. 2, fig. 8a–b.

Not *Cytherura scaberrima* BRADY, 1878, *Les fonds de la Mer*, vol. 4, p. 198, pl. 14, figs. 10, 11.

Carapace irregularly ovate in side view, strongly spinose. Anterior end very broadly and slightly obliquely rounded in the left valve, almost evenly rounded with a slightly concavity in the dorsal part in the right valve, margins in both valves denticulate; dorsal margin slightly sinuate, with spinose outline, especially in the anterior half, depressed between the projecting cardinal angles in the left valve; ventral margin strongly sinuate, roughly parallel to the dorsal one; posterior end a subdorsal caudal process, the margin in the dorsal part concave, in the ventral part broadly convex and denticulate. Left valve overlapping the right at both cardinal angles.

Ventral part of the carapace strongly swollen and divided into two swellings by a deep, curved, vertical, median sulcus, which starts just below and in front of the middle of the dorsal margin. Both swellings culminate in a strong, laterally projecting spine. Small spines, many of them flattened and blade-like in appearance, are scattered over the surface, which is smooth. A number of these spines stand in distinct rows. Two rows more or less parallel the ventral margin, the lower one obscuring it for the greater part of its existence, terminating below the posterior of the two large spines. Another row runs obliquely forward and upward from the anterior spine. Two other rows run obliquely upward and backward from the posterior spine. A row of nodular spines parallels the dorsal margin in its posterior half, below this row the swelling of the carapace begins and the dorsal region is compressed. The dorsal margin is obscured in the anterior part by a weakly convex and spinose boss. Dorsal view very irregular, ends compressed, posterior end incised in the middle, greatest width at the posterior spine but only slightly more than the width at the anterior ventral spine. The ventral view shows four curved, sinuous, rows of spines, the exterior one of which running from near the ventral margin to the anterior spine the two next ones, between the outer row and the

ventral margin end near the posterior spine. The innermost one is short; starting in the middle of the valve and running forward.

Interior of the valves deep, marginal area moderately broad in anterior end. Line of concrescence and inner margin coincide. Radial pore canals are few, slightly sinuous or straight, 8–10 in the anterior end. The strong, blade-like, inward curved, extension of the selvage in the middle of the ventral margin of the right valve is characteristic. Hinge in the right valve consists of short, terminal teeth, the posterior one of which is faintly bilobate; the median hinge element is a narrow, straight, crenulate groove. Muscle scars consist of a curved row of six scars, situated on the deepest part of the median sulcus.

Dimensions: Holotype: length 0.61 mm.; height 0.34 mm.; width 0.45 mm.

The species differs from *Bythoceratina scaberrima* (Brady) in being considerably smaller and having a less well developed anterodorsal boss. It is closely related to a new species of *Bythoceratina*, living off the coast of Trinidad, which was described by Keij (1954, p. 229, pl. 5, fig. 10) as *Bythoceratina* sp. aff. *B. utilazea* Hornibrook, which species, however, is much less spinose than the fossil one.

In the present material this species has only been found in Calyx well 57, 250–260 feet. The stratigraphic range is from lower Oligocene (*Globorobalia opima opima* zone) to middle Miocene (*Globoratalia menardii* zone).

Holotype: A right valve from Mühlemann sample 14873 at 16 foot depth, St. Croix Quarry, U.S.N.M. no. 563563; paratypes: U.S.N.M. nos. 563564 and 563565.

Genus PSEUDOCYTHERE Sars, 1927

Pseudocythere cubensis van den Bold, **new species**
Plate 5, figure 7a–b

Pseudocythere cretacea Bonnema. – VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 115, pl. 3, fig. 14a–b. – VAN DEN BOLD, 1950, Jour. Pal., vol. 24, no. 1, p. 108.

Not *Pseudocythere cretacea* BONNEMA, 1941, Natuurhist. Maandbl., vol. 30, no. 4, p. 43, pl. 7, figs. 28–30.

Carapace elongate, height less than half the length, greatest height near the anterior end, strongly produced behind. Anterior end evenly rounded; dorsal margin slightly sinuate, concave in the posterior third, convex in the middle; ventral margin strongly sinuate with a concavity just in front of the middle and forming a broad upward sweep in the posterior half, the posterior part being concave again just before reaching the dorsally situated caudal process; it bears a small spine just where the convexity changes to concavity. The posterior part of the ventral margin is strongly compressed laterally and is separated from the more tumid portion

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PLATE 1

1 *Cytherella navetensis* van den Bold, n. sp.
a, exterior of right valve, holotype, U.S.N.M. no. 563469, × 35; c, dorsal view of same valve, × 35; d, exterior of left valve, paratype, U.S.N.M. no. 563470, × 30; b, dorsal view of same left valve, × 30; e, interior of right valve, holotype, × 31. All from Renz sample 336, Friendship Quarry, *Hantkenina aragonensis* zone, middle Eocene.

2 *Cytherella harmoniensis* van den Bold, n. sp.
a, left valve view of female, holotype, U.S.N.M. no. 563472; b, dorsal view of same specimen; c, left valve view of male, paratype, U.S.N.M. no. 563473. All from Harmony Hall well 2, 601–613 feet, × 60.

3 *Cytherella stainforthi* van den Bold, n. sp.
a, left valve view of female, holotype, U.S.N.M. no. 563474; b, dorsal view of same specimen; c, left valve view of male, paratype, U.S.N.M. no. 563475. All from Stainforth 47, *Globigerina ampliapertura* zone, × 65.

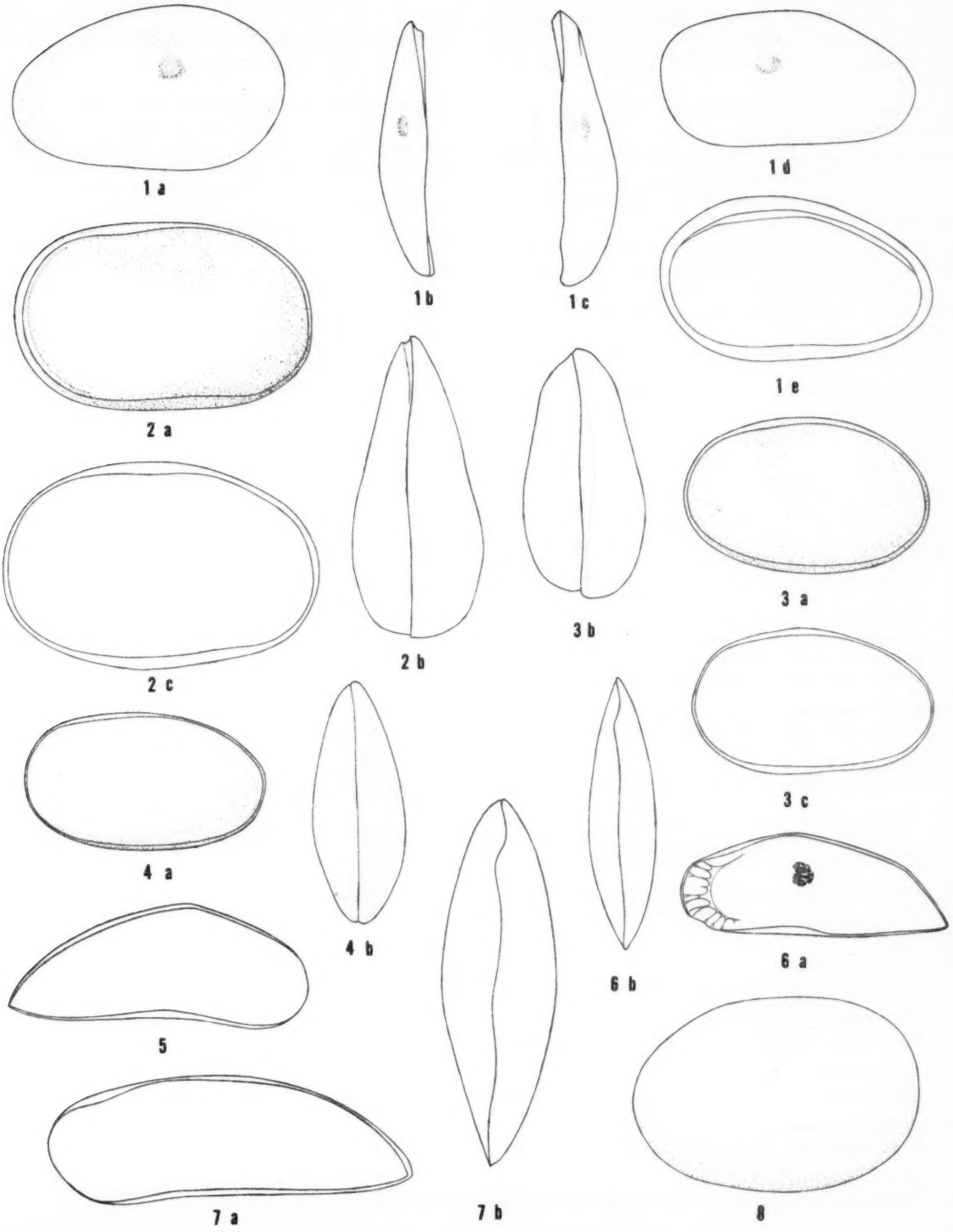
4 *Cytherella serpentiensis* van den Bold, n. sp.
a, left valve view of holotype, U.S.N.M. no. 563476; b, dorsal view of same specimen. From Kugler sample 3692, Boca de Serpiente marl, Soldado Rock, × 70.

5 *Paracypris* sp. aff. *Paracypris contracta* (Jones).
Right valve view of a complete specimen from Stainforth sample 47, *Globigerina ampliaperture* zone, × 60.

6 *Macrocypris rhodana* van den Bold, n. sp.
a, left valve view, holotype, U.S.N.M. no. 563496; b, dorsal view of same specimen. Harmony Hall well 2: 609–613 feet, × 35.

7 *Macrocypris longana* van den Bold, n. sp.
a, left valve view, holotype, U.S.N.M. no. 562493; b, dorsal view of same specimen. Harmony Hall well 2, 686–698 feet, × 35.

8 *Cytherella* sp. A.
Exterior of right valve from Stainforth sample 47, *Globigerina ampliapertura* zone, × 60.


1 a
1 b
1 c
1 d
1 e
2 a
2 b
2 c
3 a
3 b
3 c
4 a
4 b
5
6 a
6 b
7 a
7 b
8

of the carapace by a slightly concave line, running upwards from the midventral concavity to the caudal process. Dorsal view very thin, widest in front of the middle at about one third from the anterior end, both ends compressed, outline of the valves concave near the ends.

Dimensions: Holotype, length 0.58 mm.; height 0.28 mm.; width 0.18 mm.

Only two representatives of this species have been found in the upper Eocene and lower Oligocene of Trinidad, Calyx well 59, 290–310 feet and Harmony Hall well 2, 494 feet.

Holotype: A complete carapace from Tschopp sample 1147 (upper Eocene), near Nuevitas, Province of Camagüey, Cuba (Hermes, 1946, p. 11, 37–40). Coll. Min. Geol. Institute, Utrecht, no. S5805; paratypes no. S5806.

Subfamily XESTOLEBERIDINAE Sars
Genus XESTOLEBERIS Sars, 1866

Xestoleberis moriahensis van den Bold, **new species**
Plate 6, figure 9a–b

Carapace small, pyriform, highest in the middle. Anterior end obliquely rounded, low, anterodorsal slope long and convex; dorsal margin behind the greatest height slightly convex and sloping down; ventral margin slightly sinuate in front of the middle; posterior end very broadly rounded, slightly oblique, greatest convexity above the middle. Left valve overlapping the right along the entire periphery, strongest overlap along the dorsal margin. Dorsal view egg-shaped, widest behind the middle, posterior end broadly rounded, anterior end slightly angled, showing the overlap of the left valve. Surface smooth except for a few scattered papillae in the

PLATE 2

1 "*Bythocypris*" *pykna* van den Bold, n. sp.
a, interior of left valve, holotype, U.S.N.M. no. 563483, Rohr sample 18192, Lengua formation, *Globorotalia menardii* zone, middle Miocene, × 65; b, right valve view of complete carapace, paratype, U.S.N.M. no. 563485, Wirz sample 214, *Globorotalia fohsi robusta* zone, lower Miocene, × 75; c, dorsal view of same specimen; d, interior of right valve, paratype U.S.N.M. no. 563484, from Rohr sample 18192, × 75.

2 *Cardobairdia ovata* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563487, from Renz sample 385, *Porticulosphaera mexicana* zone, Navet formation, middle Eocene, × 70; b, dorsal view of same specimen; c, interior of left valve, reconstructed from broken valve from the Lengua formation, *Globorotalia mayeri* zone, augerhole in Nariva area, × 65.

3 *Bairdia caraibeensis* van den Bold.
Right valve view, Rohr sample 25684, *Globorotalia cerroazulensis* zone, upper Eocene, × 65.

4 *Bairdia* sp. C
Interior of left valve, Rohr sample 25684, *Globorotalia cerroazulensis* zone, upper Eocene, × 65.

5 *Brachycythere harmoniensis* van den Bold, n. sp.
a, right valve view of holotype, U.S.N.M. no. 563543; b, dorsal view of same specimen, Harmony Hall well 2, 828–840 feet, lower Mount Moriah silt, × 70.

6 *Brachycythere fernandensis* van den Bold, n. sp.
a, right valve view; b, dorsal view, holotype, U.S.N.M. no. 563543, from Barr sample 7244, St. Joseph village, × 65.

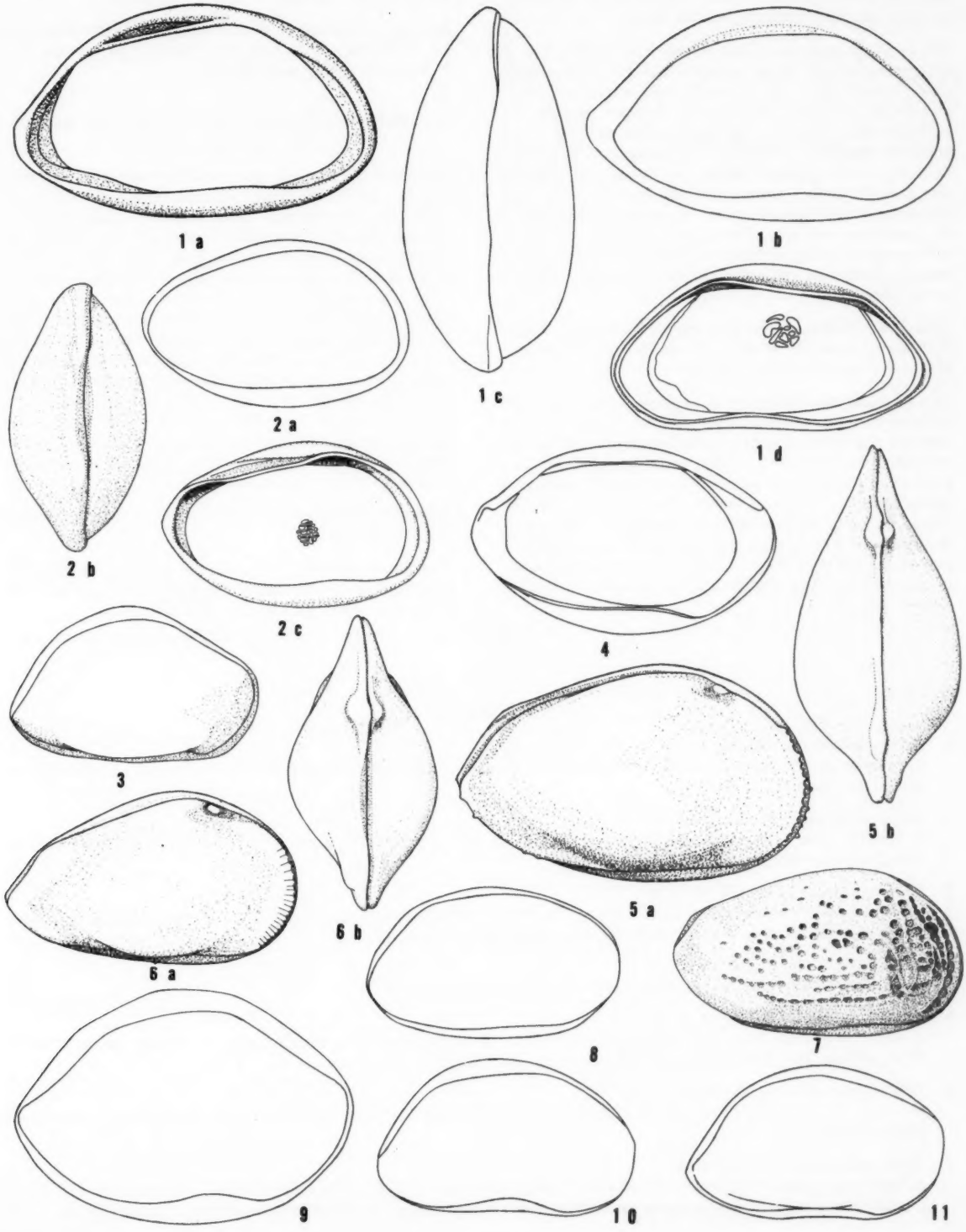
7 *Protobuntonia?* sp.
Right valve view, Harmony Hall well 2, 828–840 feet, lower Mount Moriah silt, × 65.

8 *Bairdia machaquillaensis* van den Bold
Right valve view, Esmeralda well 1, 1394–1407 feet, × 65.

9 *Bairdia* sp. *B*
Right valve view, from Rohr sample 25684, *Globorotalia cerroazulensis* zone, upper Eocene, × 65.

10 *Bythocypris cancanaensis* (van den Bold)
Right valve view, Kugler sample 8821, *Globigerapsis kugleri* zone, × 45.

11 *Bairdia* sp. *A*
Right valve view, Kugler sample 3692, Boca de Serpiente marl, Soldado Rock, × 60.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posterior portion. Muscle scars: a posterior vertical row of four with one V-shaped scar in front.

Marginal area narrow in the whole free border, line of concrescence and inner margin widely separated in anterior end, pore canals moderately numerous, short and thick; vestibule deep in the ventral part of the anterior end. Hinge in the right valve consists of an anterior, elongate crenulate tooth lying on the selvage in front of the greatest height, on the dorsal slope of the anterior end; posterior tooth also elongate and crenulate situated at the point of greatest convexity of the posterior end and extending on either side of it; in between is a deep, crenulate groove, below the dorsal margin. In the left valve are terminal elongate crenulate sockets between which is a rather broad, crenulate bar.

Dimensions: Holotype, female: length 0.45 mm.; height 0.31 mm.; width 0.30 mm.; ?male: length 0.40 mm.; height 0.27 mm.; width 0.26 mm.

In the male the carapace is highest just behind the middle; the anterodorsal slope is slightly longer and the anterior end lower; dorsal margin slightly sinuate in the left valve, straight in the right; ventral margin sinuate in front of the middle; posterior end broadly and obliquely rounded. Greatest width almost in the middle. There is only slight difference between males and females. And there is some doubt whether this separation into males and females is correct, as only males appear to occur in two samples (Stainforth sample 47, Kugler sample 3741).

Range: Upper Eocene — lower Oligocene.

Holotype: A complete female carapace from Calyx well 59, 70–80 feet, U.S.N.M. no. 563566; paratypes: U.S. N.M. nos. 563567 and 563568.

Xestoleberis chamela van den Bold, **new species**
Plate 6, figure 10a–b

Carapace pyriform in side view, highest in the middle, angular in dorsal view. Anterior end very obliquely rounded, anterodorsal slope almost straight; dorsal margin slightly convex behind the greatest height and sloping down, forming an angle of about 120° with the anterodorsal slope; ventral margin slightly convex in front of the middle, usually obscured by the overhanging tumid ventral portion of the valve, ventral side of the carapace flat; posterior end rounded upward from the ventral margin and obtusely angled against the dorsal margin above the middle. Dorsal view with broadly rounded posterior end, sides in the middle third almost parallel, slightly tapering in front. Left valve overlapping along the entire periphery with a small but regular overlap. Hinge, marginal area and muscle scars as described for *X. moriahensis*.

Dimensions: Holotype, length 0.45 mm.; height 0.30 mm.; width 0.30 mm.

The name *chamelos* (Gr.), on the ground, creeping, is suggested by the flattened ventral surface and does not imply a mode of locomotion for the species.

PLATE 3

1 *Krithe guatemalensis* van den Bold
a, exterior of left valve; b, interior of right valve. Kugler sample 1831, Lizard Springs formation, *Globorotalia rex* zone, lower Eocene, × 80.

2 *Krithe cancuenensis* van den Bold
a, interior of left valve; b, exterior of right valve. Kugler sample 1831, Lizard Springs formation, *Globorotalia rex* zone, lower Eocene, × 80.

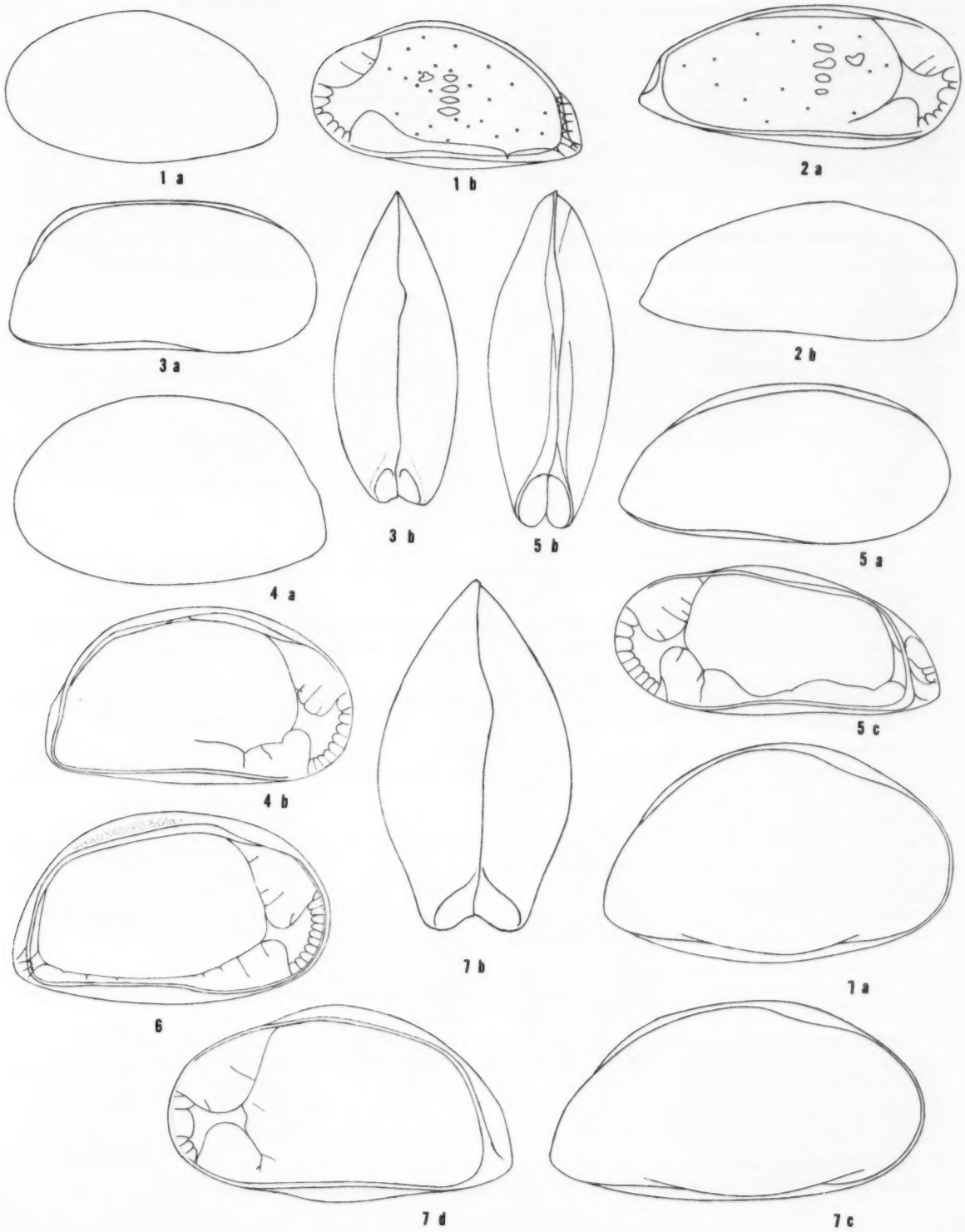
3 *Krithe saundersi* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563503; b, dorsal view of same specimen. Renz sample 385, *Porticulosphaera mexicana* zone, Navet formation, Penitence Hill marl, × 75.

4 *Krithe cubensis* van den Bold
a, exterior of left valve; b, interior of left valve. Sample SE 451, × 75.

5 *Krithe elongata* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563501; b, dorsal view of same specimen; c, interior of right valve. Wirz sample 214, *Globorotalia fohsi robusta* zone, upper Cipero marl, × 80.

6 *Krithe morkhoveni* van den Bold, n. sp.
Interior of left valve, paratype: U.S.N.M. no. 563507. Wirz sample 214, *Globorotalia fohsi robusta* zone, upper Cipero marl, × 75.

7 *Krithe crassicaudata* van den Bold
a, right valve view of female; b, dorsal view of same specimen; c, right valve view of male; d, interior of right valve, female. Sample Ky 7, *Globigerapsis semiinvoluta* zone, Hospital Hill marl, Navet formation, upper Eocene, × 75.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This species was thought for a time to represent the male of *X. moriahensis* until males were recognized in that species. It often occurs together with that species, but has a shorter vertical range. It has not been found in the *Globorotalia opima opima* zone. *Xestoleberis vicksburgensis* Howe (Howe and Law, 1936, p. 78, pl. 6, figs. 19–21) is less angular and more elongate in side view.

Holotype: A complete carapace from Calyx well 59, 266–270 feet, U.S.N.M. no. 563569; paratypes: U.S.N.M. nos. 563570 and 563571.

Xestoleberis dumblei Stephenson

Xestoleberis dumblei Stephenson, 1946, Jour. Pal., vol. 20, p. 320, pl. 43, fig. 16.

Only two specimens of this species have been found in Kugler sample 3741, Bed 4 of Kugler on Soldado Rock, which conform in every respect to the description and dimensions given by Stephenson.

Xestoleberis sp.

Plate 6, figure 11

Carapace small, ovate, highest just behind the middle. Anterior end obliquely rounded, dorsal margin convex, ventral margin nearly straight, slightly concave just in front of the middle; posterior end broadly rounded, slightly angled at the junction with the dorsal margin. Left valve overlapping the right along the entire periphery, strongest overlap along the dorsal margin. Dorsal view egg-shaped, widest behind the middle. Posterior end broadly rounded, anterior end narrowly rounded.

Dimensions: length 0.32 mm.; height 0.21 mm.; width 0.20 mm.

This species has only been found at two localities: Stainforth 47 and Kugler sample 3692 (Soldado Rock).

PLATE 4

1 *Trachyleberis bermudezi* (van den Bold)
Exterior of left valve, *Catapsydrax dissimilis* zone, lower Miocene, × 65.

2 *Trachyleberis bollii* van den Bold n. sp.
a, right valve view, holotype, U.S.N.M. no. 563521; b, dorsal view of same specimen. Renz sample 385, Penitence Hill marl, Navet formation, *Porticulosphaera mexicana* zone, middle Eocene, × 65.

3 *Trachyleberis? hapsida* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563524; b, dorsal view of same specimen. Kugler sample 3692, Boca de Serpiente marl, Soldado Rock, × 65.

4 *Costa barri*, van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. 563526; b, dorsal view same of specimen. Barr sample 7244, St. Joseph village, San Fernando, × 65.

5 *Costa lehneri* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563528; b, dorsal view of same specimen. Calyx well 57, 250–260 feet, *Globorotalia opima opima* zone, Oligocene, × 70.

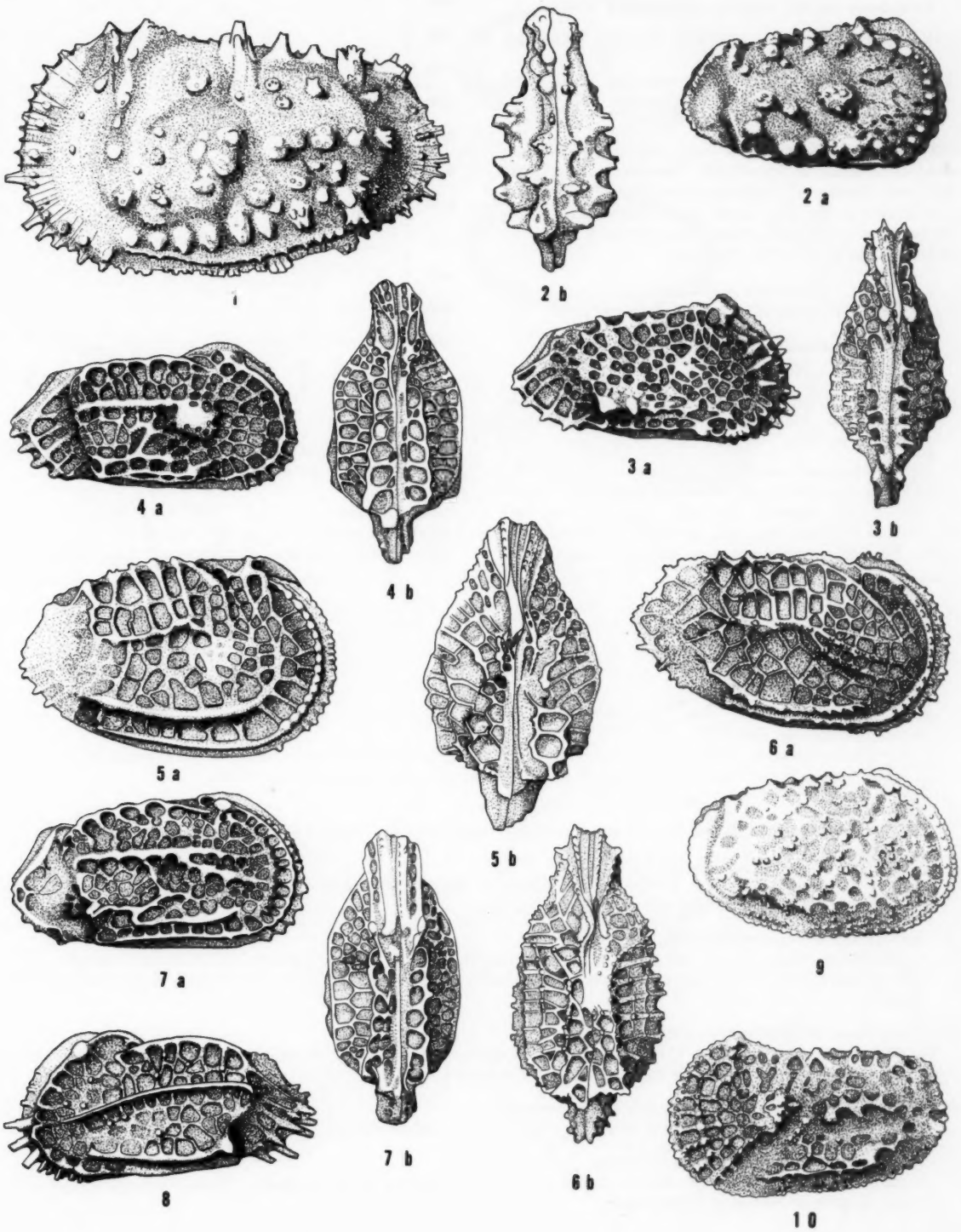
6 *Costa harmoniensis* van den Bold, n. sp,
a, right valve view, holotype, U.S.N.M. no. 563530; b, dorsal view of same specimen. Calyx well 57, 910–920 feet, *Globigerina ampliapertura* zone, lower Oligocene, × 70.

7 *Costa meka* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563535; b, dorsal view of same specimen. Harmony Hall well 2, 1988–2000 feet, lower Mount Moriah silt, × 70.

8 *Cativella moriahensis* van den Bold, n. sp.
Exterior of left valve, holotype, U.S.N.M. no. 563539, Stainforth sample 47, *Globigerina ampliapertura* zone, lower Oligocene, × 70.

9 *Echinocythereis okeechobiensis* (Swain)
Right valve view, Calyx well 59, 430–440 feet, *Globorotalia cerroazulensis* zone, × 60.

10 *Henryhowella asperrima* (Reuss)
Exterior of left valve, Calyx well 57, 850–860 feet, *Globigerina ampliapertura* zone, lower Oligocene, × 65.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Genus UROLEBERIS Triebel, 1958

Uroleberis sp. aff. **Cythere ranikotiana** Latham

?*Cythere ranikotiana* LATHAM, 1936, Proc. Roy. Soc. Edinburgh, vol. 59, p. 41, fig. 4a–b.

Xestoleberis ranikotiana (Latham)?. – VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, p. 121, pl. 17, fig. 4a–b.

Only a few specimens that may belong to Latham's species and which are identical to the ones described from the lower Eocene of Guatemala and British Honduras, were found in the Fitt Trace marl (Renz 335), *Globorotalia lehneri* zone, and in the *Truncorotaloides rohri* zone of Esmeralda well 1, 380–394 feet.

INCERTA SUBFAMILIA

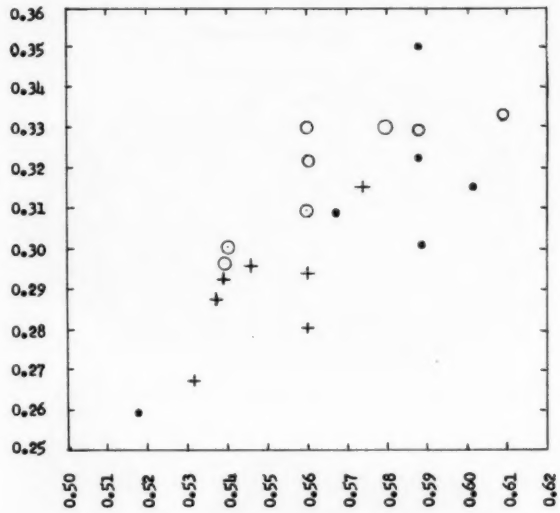
Genus RUTTENELLA van den Bold, 1946

Ruttenella ovata van den Bold

Plate 5, figure 1a–f

Ruttenella ovata VAN DEN BOLD, 1946, Contribution to the study of Ostracoda, Univ. Thesis, Utrecht, pp. 84–85, pl. 7, fig. 3a–b, pl. 9, fig. 13a–b.

Carapace elongate ovate, highest just in front of the middle. Anterior end evenly rounded; dorsal and ventral margin convex, posterior end subtruncate above, narrowly rounded and minutely denticulate below; posterior cardinal angle projecting in both valves, more conspicuously in the left. Left valve larger than the right and overlapping along ventral margin, anterior end, anterior portion of the dorsal margin, posterior



TEXT-FIGURE 5

Length and height ratio of *Ruttenella ovata* van den Bold. • Trinidad; ○ Bonaire; + Venezuela.

PLATE 5

1 *Ruttenella ovata* van den Bold
a, right valve view; b, dorsal view, c, interior of left valve, d, interior of right valve, e, dorsal view of left valve, f, dorsal view of right valve. From marl at Porto Spaño, Bonaire, upper Eocene, × 80.

2 *Buntonia*? sp.
a, right valve view, b, dorsal view. Pauji formation, upper Eocene, western Venezuela, × 80.

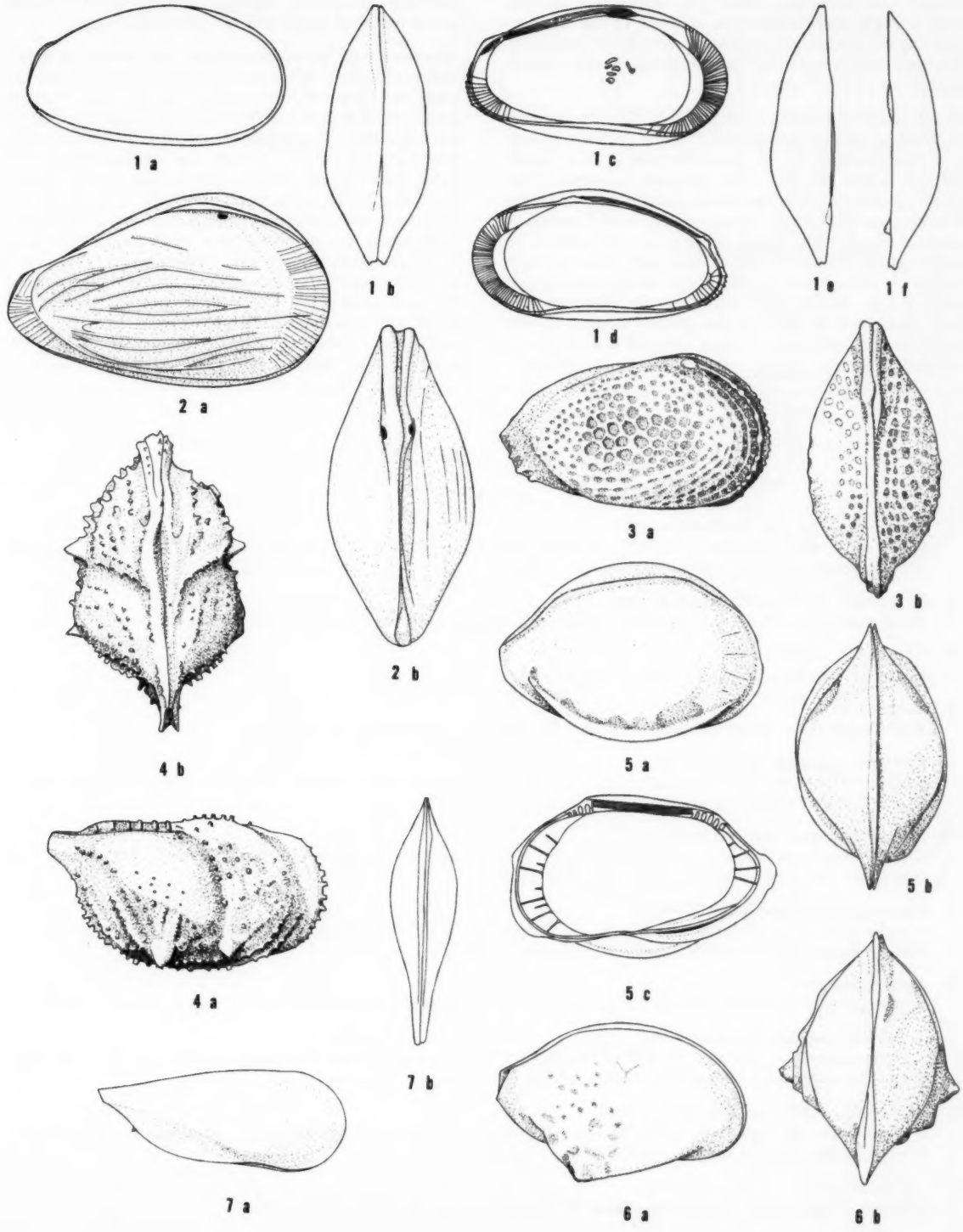
3 *Bosquetina? concepcionensis* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563546; b, dorsal view, same specimen. Esmeralda well, 2630–2650 feet, "*Gaudryina* beds," middle or lower Eocene, × 80.

4 *Bythoceratina scabra* van den Bold, n. sp.
a, exterior of right valve, holotype, U.S.N.M. no. 563566, St. Croix Quarry, Mühlemann sample 14813, *Globigerinatella insueta* zone, lower Miocene; b, dorsal view of paratype, U.S.N.M. no. 563567, Kugler sample 2845, × 80.

5 *Cytheropteron? trinidadensis* van den Bold, n. sp.,
a, right valve view, holotype, U.S.N.M. no. 563557, Barr sample 7689; b, dorsal view of same specimen; c, interior of right valve, paratype, U.S.N.M. no. 563558, Rohr sample 18773, × 70.

6 *Cytheropteron* sp., aff. *Cytheropteron tricorne* (Bornemann)
a, right valve view, b, dorsal view of same specimen. Barr sample 7244a, × 70.

7 *Pseudocythere cubensis* van den Bold, n. sp.
a, right valve view, holotype, M-GIU, S5805; b, dorsal view of same specimen. From Tschopp sample 1147, upper Eocene of Nuevitas, Cuba, × 80.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6 b
7 a
7 b

cardinal angle and dorsal part of the posterior end. Dorsal view elongate, widest just behind the middle with a slight compression just anterior to the middle; anterior end fairly acute, posterior end slightly irregular, due to a small projecting, spinose flange in the ventral part.

Hinge in the left valve consists of an elongate, weakly denticulate socket, just anterior to the greatest height and just posterior to an incurved part of the dorsal margin, where the left valve overlaps the right. The socket continues below the dorsal margin and separates it from a narrow, finely crenulate bar; at the posterior cardinal angle the dorsal margin curves around a socket which is open to the interior and which is connected to the groove in the dorsal margin above the median bar. In the right valve an elongate, dentate area occurs just in front of the greatest height; at the posterior cardinal angle a short, dentate area is found consisting of two cusps; between the two terminal dentate areas is a narrow and shallow groove which is probably denticulate, although this could not be seen in the material in my private collection.

Marginal area broad in anterior end; vestibule sickle-shaped; line of concrescence parallels the outer margin, separated from the inner margin. In the small anterior area, where line of concrescence and inner margin do not coincide, the pore canals are numerous, about fifty. They are curved away from the median line of the valve, upward and backward in the upper half, downward and backward in the lower half. In the posterior end about ten radial canals occur, ending in the denticules which are mounted on a small flange extending backward from the selvage. Muscle scars: a posterior row of four scars, the second from the top being divided into two small scars. Shape of the scars is rather irregular, the upper one is slightly oblique. In front of this vertical row a single V-shaped scar occurs of which the posterior leg is much longer than the anterior one.

PLATE 6

1 *Argilloecia nutusa* van den Bold, n. sp.
a, left valve view, holotype, U.S.N.M. no. 563478; b, dorsal view of same specimen. Stainforth sample 47, *Globigerina ampliapertura* zone, lower Oligocene, × 100.

2 "*Krausella*" aff. *Krausella minuta* Triebel
Right valve view, Rohr sample 4347a, *Globorotalia rohri* zone, Navet formation, middle Eocene, × 95.

3 "*Krausella*" *minuta* Triebel
Hinge of right valve, Upper Cretaceous, Holland, × 130.

4 *Eucythere* sp.
Right valve view, Esmeralda well 1, 2630–2650 feet, "*Gaudryina* beds," × 105.

5 *Parakrithe waitei* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563508; b, dorsal view of same specimen. Harmony Hall well 2, 865 feet, lower Mount Moriah silt, upper Eocene, × 100.

6 *Parakrithe elongata* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563513; b, dorsal view of same specimen. Harmony Hall well 1, 865 feet, lower Mount Moriah silt, upper Eocene, × 105.

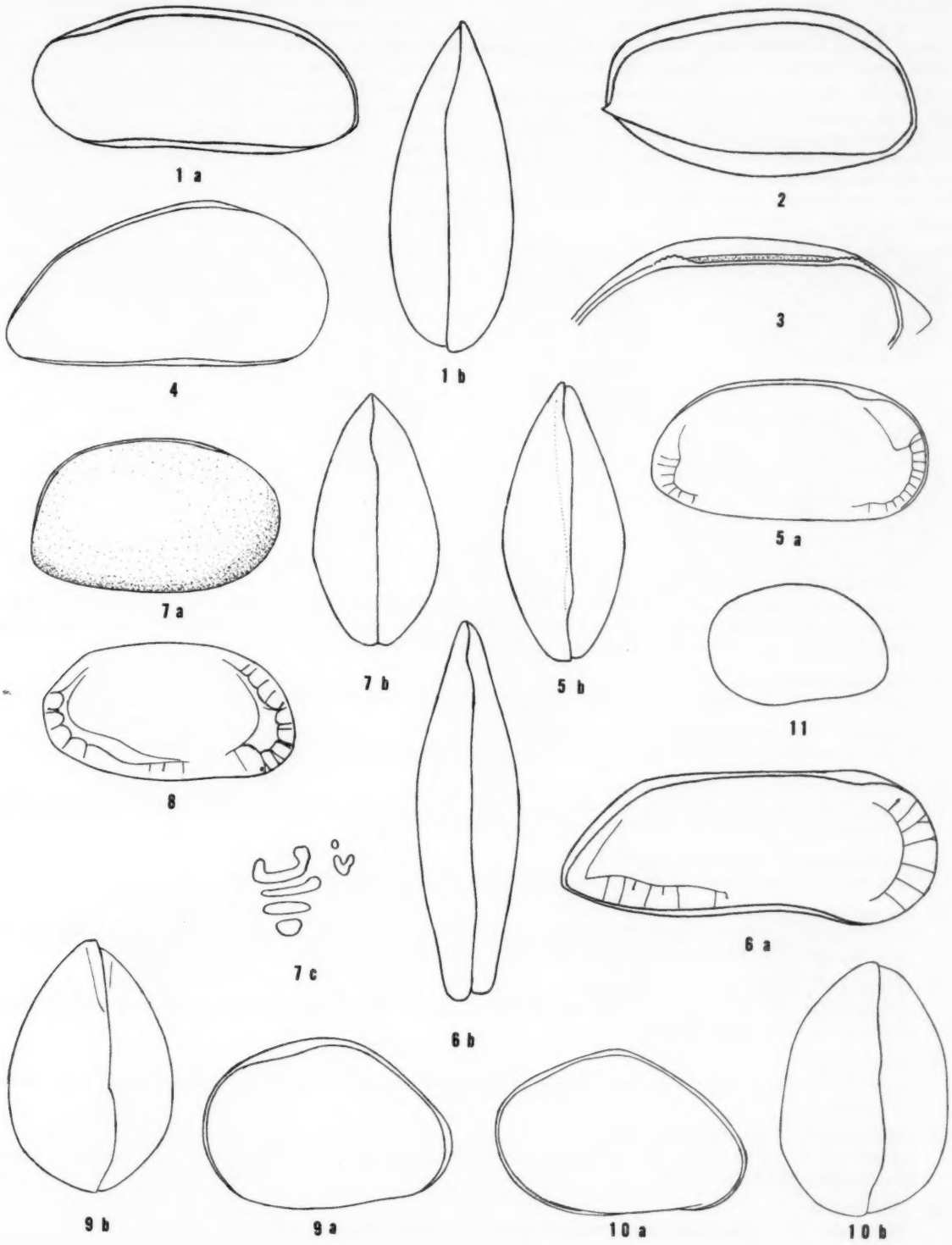
7 *Parakrithe? ovata* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563510, × 105; b, dorsal view of same specimen; c, muscle scar. Sample Renz. 384, Vistabella marl, upper Eocene, × 230

8 *Microcythere?* sp.
Right valve view, Kugler sample 3741, *Globorotalia cerroazulensis* zone, Soldado Rock, upper Eocene, × 105.

9 *Xestoleberis moriahensis* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563567; b, dorsal view of same specimen. Calyx well 59, 70–80 feet, *Globigerina ampliapertura* zone, lower Oligocene, × 100.

10 *Xestoleberis chamela* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563569; b, dorsal view of same specimen. Calyx well 59, 266–270 feet, *Globigerina ampliapertura* zone, lower Oligocene, × 100.

11 *Xestoleberis* sp.
Exterior of right valve, Stainforth sample 47, *Globigerina ampliapertura* zone, × 100.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Dimensions: Length 0.61 mm.; height 0.33 mm.; width 0.24 mm. (complete figured carapace). Variation: ?female, length 0.48–0.61 mm.; height 0.26–0.35 mm.; ?male, length 0.52–0.61 mm.; height 0.25–0.32 mm.

This species, which so far is the only one described for the genus, appears to be confined to the upper Eocene. In Trinidad it occurs in the San Fernando formation (Vistabella marl, Boca de Serpiente marl, Calyx well 59, 430–440 feet, Harmony Hall well 2, 650–662 feet). It has also been found in the Pauji and Paloma Alta shales of western Venezuela.

The species was originally described from a marl found in a hand-dug well near Porta Spaño, Columbia plantation on Bonaire (Pijpers, 1933, p. 41). Pijpers' determinations of the smaller foraminifera of this marl were later emended by Drooger (1953, p. 94, 95), who lists among the planktonic foraminifera: *Globorotalia cocoaensis, crassata, centralis* and *lehneri, Globigerina bulloides, eocenica, dissimilis* and *danvillensis, Globigerinoides mexicana, pseudodubia.* The occurrence together in one sample of some of these species is in conflict with the ranges as given by Bolli (1957, p. 159), but Drooger remarks (p. 96) that there are "a number of individuals, approaching the types of *Globigerinoides mexicana* and *Globigerinoides index*". If we assume Drooger's identification of *Globorotalia bonairensis* Pijpers with *Globorotalia cerroazulensis* to be correct, this would probably place this marl in the higher part of the upper Eocene and correlate it with the San Fernando formation.

PLATE 7

1 *Munseyella reticulata* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 563517; b, dorsal view of same specimen, Kugler sample 3741, *Globorotalia cerroazulensis* zone, Soldado Rock; c, interior of right valve, paratype; d, interior of left valve of same specimen, U.S.N.M. no. 563520, Harmony Hall well 2, 1988–2000 feet, × 105.

2 *Munseyella* sp.
Left valve view, Esmeralda well 1, 3052–3071 feet, "*Gaudryina* beds," × 100.

3 *Munseyella israelskyi* Marianos and Valentine
Right valve view, Esmeralda well 1, 3052–3071 feet, "*Gaudryina* beds," × 100.

4 *Loxoconcha wagneri* van den Bold n. sp.
a, right valve view, holotype, U.S.N.M. no. 563547; b, dorsal view of same specimen, Kugler sample 3741, *Globorotalia cerroazulensis* zone, Soldado Rock, upper Eocene, × 90.

5 *Loxoconcha* sp. aff. *Loxoconcha diverta* Murray
Left valve view, well near La Brea, Pitch Lake, lower Oligocene, × 100.

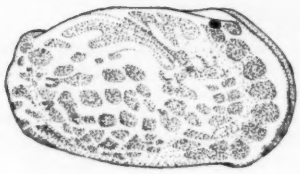
6 *Loxoconcha* sp.
a, exterior of right valve, Aripero, Texaco Trinidad Cat. no. 123554, *Catapsydrax dissimilis* zone; b, dorsal view of complete specimen, Calyx well 103, 140–150 feet; c, interior of right valve, same specimen as 6a, × 105.

7 *Cytherura vistabellensis* van den Bold, n. sp.
a, right valve view, holotype, U.S.N.M. no. 565521; b, dorsal view of same specimen, Stainforth 47, *Globigerina ampliapertura* zone, lower Oligocene, × 110.

8 *Cytherura*? sp.
a, exterior of right valve, b, interior of same valve, Stainforth sample 47, *Globigerina ampliapertura* zone, lower Oligocene, × 105.

9 *Eucytherura kugleri* van den Bold, n. sp.
a, right valve view; b, dorsal view of same specimen, Kugler sample 3741, *Globorotalia cerroazulensis* zone, upper Eocene, Soldado Rock, × 100.

10 *Eucytherura* sp.
Right valve view, Esmeralda well 1, 2630–2650 feet, "*Gaudryina* beds," × 105.



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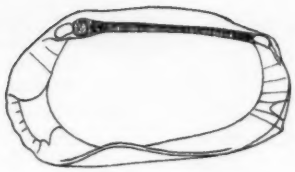

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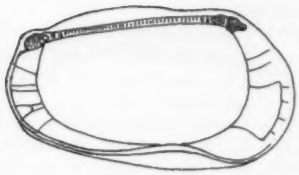

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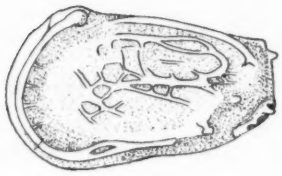

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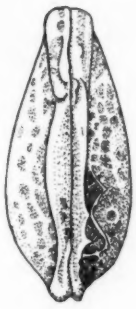

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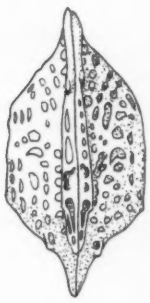

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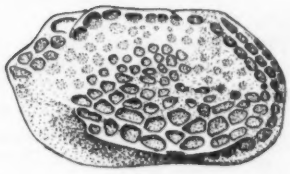

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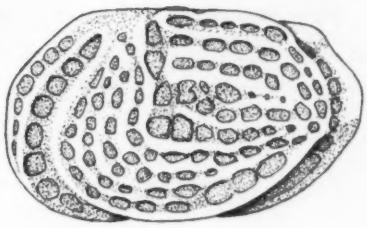

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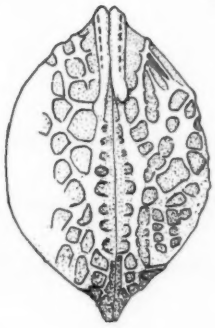

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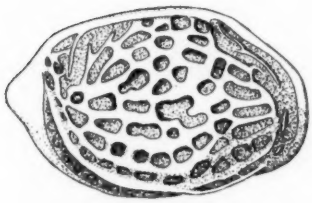

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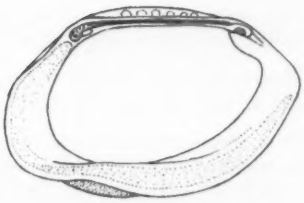

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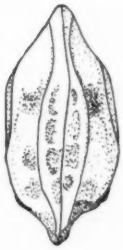

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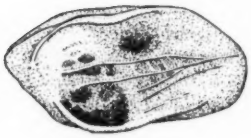

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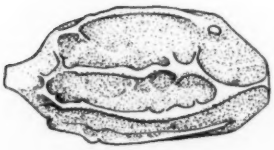

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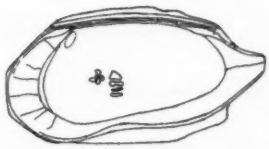

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PLATE 8

1 *Trachyleberis bermudesi* (van den Bold)
Interior of right valve, Calyx well 57, 830–840 feet, *Globigerina ampliapertura* zone, lower Oligocene, × 75.

2 *Henryhowella asperrima* (Reuss)
Interior of right valve, Calyx well 57, 850–860 feet, *Globigerina ampliapertura* zone, lower Oligocene, × 80.

3 *Henryhowella evax* (Ulrich and Bassler)
Dorsal view of hinge in right valve, Calvert formation, Plum Point, Maryland, × 60.

4 *Costa lehneri* van den Bold, n. sp.
a, interior of right valve, paratype, U.S.N.M. no. 563529; b, dorsal view of hinge in right and left valves, Calyx well 57, 250–260 feet, *Globigerina ampliapertura* zone, lower Oligocene, × 75.

5 *Cativella moriahensis* van den Bold, n. sp.
Interior of left valve, Harmony Hall well 2, 1988–2000 feet, lower Mount Moriah silt, × 80.

6 *Ambocythere elongata* van den Bold
Interior of right valve, Calyx well 57, 258–260 feet, *Globorotalia opima opima* zone, Oligocene, × 130.

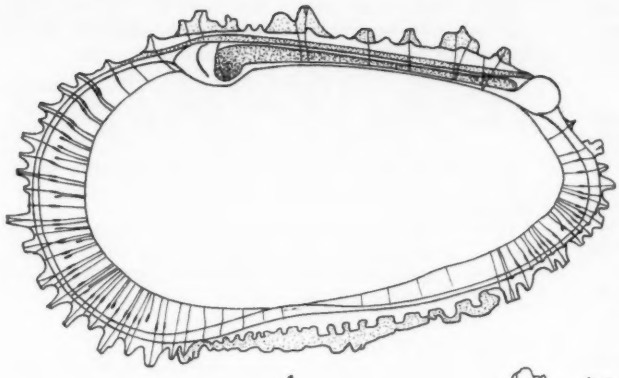
7 *Hermanites?* sp.
Right valve view, Esmeralda well 1, 2630–2650 feet, "*Gaudryina* beds", × 80.

8 *Quadracythere?* sp.
Right valve view, Kugler sample 3741, *Globorotalia cerroazulensis* zone, upper Eocene, Soldado Rock, × 80.

9 *Occultocythereis?* sp.
Right valve view, Esmeralda well 1, 2630–2650 feet, "*Gaudryina* beds", × 80.

10 *Hermanites?* sp. aff. *paijenborchiana* Keij
Left valve, Stainforth sample 47, *Globigerina ampliapertura* zone, lower Oligocene, × 80.

11 *Buntonia?* sp.
a, interior of right valve; b, dorsal view of hinge of right valve, Pauji formation, upper Eocene, western Venezuela, × 80.



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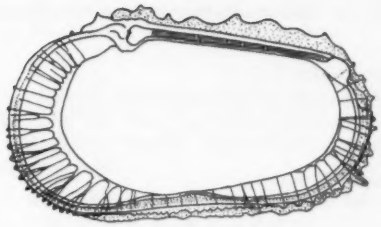

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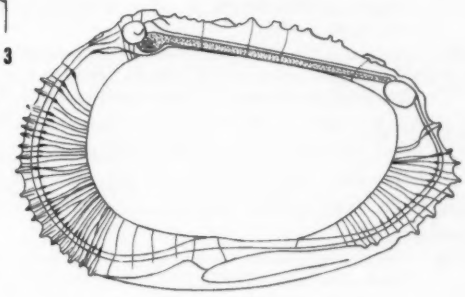

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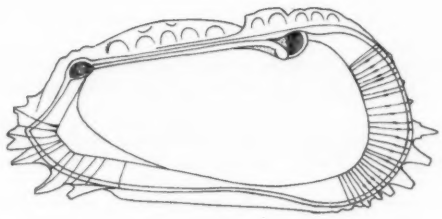

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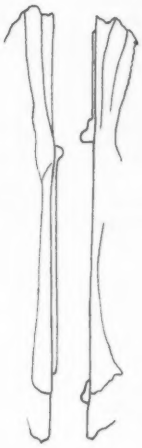

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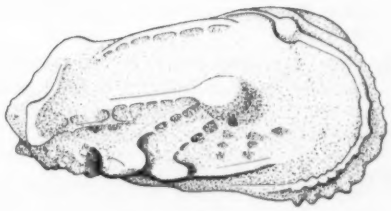

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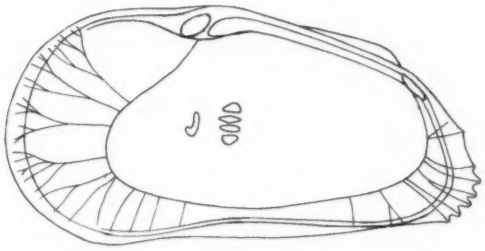

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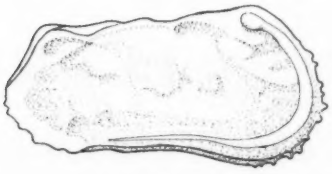

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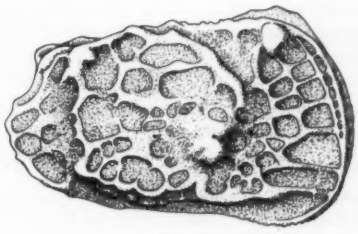

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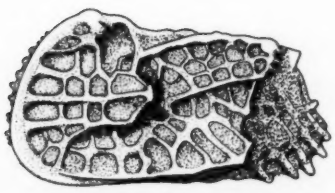

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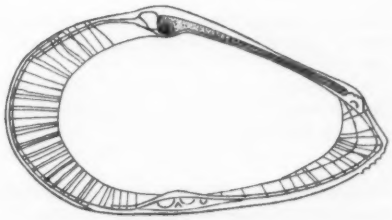

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ABSTRACT: *Seven new species of microfossils from the Buildwas Shales (Wenlockian) of England are described. They are grouped with the hystrichospheres and assigned to two new genera,* Deunffia *and* Domasia. Veryhachium monacanthum *Deunff is transferred to* Deunffia.

Deunffia and Domasia, new genera of hystrichospheres

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INTRODUCTION

In 1951 Deunff described a new species of microfossil from the Upper Ordovician of Brittany, France, calling it *Hystrichosphaeridium monacanthum*. He later (1954) transferred it to the genus *Veryhachium*, which he established for hystrichospheres with few processes and rather polygonal tests. This species, however, is outstanding, having only one long flagella-like process and an ellipsoidal test. Consequently, in a recent paper (1958) he queried its assignment to *Veryhachium*.

Up to the present, no other similar species has been described. However, a number of organisms, apparently related to each other, have recently been found in the Wenlock of England, some of which resemble Deunff's species very closely. It is proposed to assign these new forms, together with Deunff's species, to two new genera *Deunffia* and *Domasia*.

LOCALITY AND HORIZON

The new species here described were found in samples of the Buildwas Shale division of the Wenlock Shales from the type area near Much Wenlock, Shropshire, England. Two samples were examined, both from Harley Brook at Domas farm near locality 30 of the Geological Survey Memoir (Pocock *et al.*, 1938, fig. 17). The first (BS/1) was a soft grey shale lying about five feet above the base of the Wenlock Shales, 100 yards downstream from the bridge below the farm (Ordnance Survey of Great Britain, Grid Reference 35/596008). The second (BS/2) was a calcareous nodule from grey clays lying about 50 feet above BS/1 from an exposure 150 yards upstream from the bridge (Grid Ref. 33/594006). At both localities the rocks contained a marine fauna composed mainly of small brachiopods.

Hot hydrofluoric acid was used to break up the rocks and the residue was mounted in glycerine jelly. Oxidization was unnecessary. Slides were made of the unsorted residue and also of specially picked individuals. The types are at present in the collections of the Department of Geology at the University of Sheffield.

DISCUSSION OF GENERA

When Deunff (1954) created the genus *Veryhachium* he made it clear that he intended it to embrace those hystrichospheres with relatively few processes, the shape of whose test, being determined mainly by the number of processes, was more or less polygonal. *V. monacanthum*, however, does not closely resemble the other species he assigned to the genus, for it has only a single process and an ellipsoidal body. Presumably for these reasons, Deunff (1958) queried his assignment of the species to *Veryhachium* and stated it was only provisional.

Three other species have now been found having a single long process and an ellipsoidal body as in *V. monacanthum* and they, together with Deunff's species, are placed in a new genus, *Deunffia*. Another three species found in the same preparations resemble *Deunffia* in the form and substance of the body and the structure of the processes, but differ in having two long processes at one pole and at the opposing pole a single process of variable length. Among the hystrichospheres described so far the only species resembling these trispinose forms is *V. trisulcum* Deunff. This species, however, has a triangular test and processes all of the same length, so that it clearly belongs to the genus *Veryhachium*. It is proposed, therefore, to assign the new forms with ellipsoidal tests and unequal processes to a new genus, *Domasia*.

Examination of the literature dealing with living organisms has failed to show any which resemble either *Deunffia* or *Domasia* closely. *Deunffia brevispinosa* and *D. monacantha* show some similarity in shape and size to certain species of *Actinastrum* (Pascher 1915, figs. 240–1, p. 169), but this genus normally forms loose colonies in fresh water and appears to be entirely absent in marine waters (Fritsch, 1935, p. 147). No species among living organisms appears to bear any resemblance to any of the species of *Domasia* or to *Deunffia furcata* or *D. ramusculosa*.

There is a morphological resemblance between the species of *Deunffia* having simple spines and *Pareodinia* Deflandre, a dinoflagellate common in the Upper Juras-

sic, but, in addition to being separated from *Deunffia* by a great gap in time, this genus has an apical process that is always short, broad and rather rounded. Furthermore, there is generally a line of weakness indicated by folding where the equatorial furrow would be expected to occur which is never present in *Deunffia* (Sarjeant, personal communication).

The closest comparison in mode of occurrence, age and morphology is undoubtedly with the hystrichospheres. The resemblance of *Domasia trispinosa* to *V. trisulcum* and the original assignment of *Deunffia monacanthum* to *Hystrichosphaeridium* testify to this. Classifying them with the hystrichospheres does not, however, make their true nature any clearer, this group having been considered at different times as desmid spores, possible dinoflagellate cysts or radiolaria. The problem has been discussed at some length by Deflandre (1947) and Eisenack (1954).

COMPARISON OF THE SAMPLES

Deunffia and *Domasia* together form 3% of the total number of hystrichospheres examined in sample BS/1, and 12% in sample BS/2. Some of the species are rare. Table 1 shows their distribution and it can be seen that sample BS/1 is characterised by the abundance of *D. monospinosa*, associated with *D. ramusculosa*, *Domasia trispinosa* and *D. bispinosa*, whereas sample BS/2 is characterised by the predominance of *Deunffia furcata*.

TABLE 1

NUMBER OF INDIVIDUALS IN EACH SAMPLE*

Species	Sample number BS/1	BS/2
Deunffia monospinosa	17	3
Deunffia brevispinosa	8	0
Deunffia ramusculosa	5	0
Deunffia furcata	0	20
Domasia trispinosa	2	0
Domasia bispinosa	1	0
Domasia elongata	0	1

*Subsequent work has greatly increased these numbers; the proportions, however, remain more or less unchanged.

None of these species has been found in any of several samples from the higher divisions of the Wenlock Shales in this region, but whether or not they are characteristic of the Buildwas Shales must remain undecided until the underlying Llandovery beds have been examined.

SYSTEMATIC DESCRIPTIONS

Order HYSTRICHOSPHAERIDEA
Family INCERTA SEDIS

Genus **Deunffia** Downie, **new genus**

Genotype: *Deunffia monospinosa* Downie, new species.

Definition: Shell hollow, elongate ellipsoidal, more or less smooth, less than 100μ in length. Body composed of thin, pale yellow to brown, organic membrane. Ornament consisting of a single hollow spine situated at one end. Spine terminates in a point or branches in various ways.

Deunffia monospinosa Downie, **new species**
Plate 1, figure 8

Holotype: The specimen figured in Plate 1, figure 8, slide no. BS/1a/17; Shropshire, England; Buildwas Shales, Wenlockian.

Description: The hollow ellipsoidal body is pale yellow-green with a smooth matte surface, the matte appearance probably being due to a very fine granulation. In every specimen the interior is quite empty. The longer dimension of the body is about 17μ, the single hollow spine is about twice this length and narrows gradually to terminate in a hairlike tip. The cavity of the spine is frequently divided into compartments by irregularly spaced partitions.

Dimensions: Holotype: body 17.5μ long, 6μ wide (slightly squashed), spine 50μ long, 1.5μ wide at base. Size range (of 20 specimens): body 15–20μ long, 6–10μ wide, ratio of spine length to body length 1.5/2.8.

Occurrence: Buildwas Shales, samples BS/1 and BS/2, Harley Brook, Domas, Shropshire.

Deunffia monacantha (Deunff)

Hystrichosphaeridium monacanthum DEUNFF, 1951, Acad. Sci., C. R., vol. 233, pp. 321–323, fig. 4.

Veryhachium monacanthum DEUNFF, 1954, Soc. Géol. France, C. R., no. 13, pp. 305–307.

Veryhachium (?)*monacanthum* DEUNFF, 1958, Soc. Géol. Min. Bretagne, Bull., n. ser., vol. 2, pp. 1–41, pl. 1, figs. 18, 24.

Remarks: This species has been recorded only from the Schistes du Veryhac'h (Caradocian) of Brittany, France. It is larger than *D. monospinosa*, the body being about 50μ long. Furthermore, the body is more spherical and the spine, which is relatively narrower, rises more abruptly from the test. Deunff has observed deposits of organic substance within the test which he considered to be possibly connected with encystment. Similar structures have not been observed in the other species of *Deunffia*.

Deunffia brevispinosa Downie, **new species**
Plate 1, figures 4, 6

Holotype: The specimen figured in Plate 1, figure 6, slide no. BS/1a/16; Shropshire, England; Buildwas Shales, Wenlockian.

Description: The hollow ellipsoidal body is pale yellow-green with a smooth matte surface. In every specimen the interior is empty. The longer dimension of the body is about 17μ, the single hollow spine is about half this

length, and narrows steadily to a pointed tip. The cavity of the spine may be divided by partitions. The surface of the spine is covered by small granules distally.

Dimensions: Holotype: body 17μ long, 7μ wide (slightly squashed), spine 11μ long, 1.5μ wide at base. Size range (of 8 specimens): body 15–20μ long, 7–11μ wide, ratio of spine length to body length 0.55/0.67.

Occurrence: Buildwas Shales, sample BS/1 only, Harley Brook, Domas, Shropshire.

Comparisons: D. brevispinosa resembles *D. monospinosa* very closely in the shape, size and texture of the body, but is readily distinguished by its shorter spine with granular tip.

Deunffia ramusculosa Downie, **new species**
Plate 1, figure 2

Holotype: The specimen figured in Plate 1, figure 2, slide no. BS/1a/2; Shropshire, England; Buildwas Shales, Wenlockian.

Description: The hollow ellipsoidal body is pale yellow-green with a smooth matte surface. In every specimen the interior is empty. The longer dimension of the body is about 17μ. The single hollow spine is over twice this length and branches at the tip. Text-figures 1–5 show variations in the branching. It can be seen that the difference lies mainly in the number of branches. The angle with the main shaft is always about 90 degrees, the tips are always rounded and the length remains constant about 2.5μ. The point of divergence at the distal point of the main shaft was not clearly visible in any of the specimens but it is believed that the wall flares abruptly forming an open funnel from the edge of which the spines arise.

Dimensions: Holotype: body 19μ long, 10μ wide (slightly squashed), spine 45μ long, 1.5μ wide at base, branches 2.5μ long. Size range (of 5 specimens): body 15–19μ long, 7–10μ wide, ratio of spine length to body length 2.4/3.2.

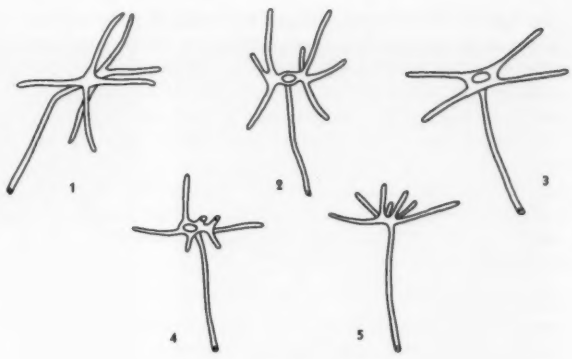
Occurrence: Buildwas Shales, sample BS/1 only, Harley Brook, Domas, Shropshire.

Comparisons: D. ramusculosa resembles *D. monospinosa* very closely but can be easily distinguished in unbroken specimens by the branching at the tip.

Deunffia furcata Downie, **new species**
Plate 1, figures 1, 9

Holotype: The specimen figured in Plate 1, figures 1 and 9, slide no. BS/2a/7; Shropshire, England; Buildwas Shales, Wenlockian.

Description: The hollow ellipsoidal body is pale yellow-green with a smooth matte surface. In every specimen the interior is empty. The longer dimension of the body is about 17μ, the single hollow spine is about one and a



TEXT-FIGURES 1–5

Deunffia ramusculosa Downie, n. sp. Details of branching at the spine tip: 1, lateral view of holotype; 2, reconstructed polar view of holotype; 3, oblique view of another specimen with few branches; 4, polar view of a third specimen; 5, reconstructed lateral view of same specimen.

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half times this length, and distally bifurcates into two long curving branches becoming hair-like at their tips. The angle between the branches is about 180 degrees. It is common to find the cavity, both of the main shaft and the branches, divided by partitions into irregular compartments.

Dimensions: Holotype: body 17μ long, 7μ wide (slightly squashed), shaft of spine 27μ long, 1.5μ wide at base, branches 24μ long, 1μ wide at base. Size range (of 20 specimens): body 15–20μ long, 7–10μ wide, ratio of spine shaft to body length 1.0/1.8, branch length to body length 0.7/1.7.

Occurrence: Buildwas Shales, sample BS/2 only. Harley Brook, Domas, Shropshire.

Comparisons: D. furcata resembles *D. monospinosa* and *D. ramusculosa* but can be readily distinguished by the two long branches at the tip of the spine.

Domasia Downie, **new genus**

Genotype: Domasia trispinosa Downie, new species.

Definition: Shell hollow, elongate, ellipsoidal, more or less smooth, about 20μ in length. Body composed of pale yellow to brown organic membrane. Ornament consisting of two relatively long hollow spines arising near one pole and a single spine of variable length at the opposing pole.

Domasia trispinosa Downie, **new species**
Plate 1, figure 7

Holotype: The specimen figured in Plate 1, figure 7, slide no. BS/1a/14; Shropshire, England; Buildwas Shales, Wendlockian.

Description: The hollow ellipsoidal body is pale yellow-green with a smooth matte surface. In every specimen the interior is empty. The longer dimension of the body is about 17μ. Two similar hollow spines of a length about equal to that of the body occur at one end (anterior). The spine bases are separate and merge with the test wall, distally they narrow steadily to a point. In some instances these spines are divided by internal septa. The single posterior spine is only a little shorter but is much narrower and it cannot be determined whether or not it is hollow.

Dimensions: Holotype: body 20μ long, 10μ wide; anterior spines 18μ long, 2.5μ apart at base, bases 1.2μ wide; posterior spine 15μ long, less than 1μ wide at base. The only other specimen measured was of a similar size.

Occurrence: Buildwas Shales, sample BS/1 only, Harley Brook, Domas, Shropshire.

Domasia bispinosa Downie, **new species**
Plate 1, figure 3

Holotype: The specimen figured in Plate 1, figure 3, slide no. BS/1a/15; Shropshire, England; Buildwas Shales, Wenlockian.

Description: The hollow ellipsoidal body is pale yellow-green with a smooth matte surface. The interior is empty. The longer dimension of the body is about 17μ. Two similar hollow spines of a length about equal to that of the body occur at the anterior end. The spine bases are separate and merge with the test wall, distally they narrow steadily to a point, and are faintly granular. The cavity of the spines is divided into compartments by irregular septa. The posterior spine is very short and easily escapes notice, being about 1μ long.

Dimensions: Holotype: body 17μ long, 10μ wide; anterior spines 17μ long, 3μ apart at base, bases 1.5μ wide; posterior spine 1μ long.

Occurrence: Buildwas Shales, sample BS/1 only, Harley Brook, Domas, Shropshire.

Comparisons: D. bispinosa resembles *D. trispinosa* but the posterior spine is so short that it appears, as its name suggests, to have only two spines except at very high magnifications.

Domasia elongata Downie, **new species**
Plate 1, figure 5

Holotype: The specimen figured in Plate 1, figure 5, slide no. BS/2a/5; Shropshire, England; Buildwas Shales, Wenlockian.

Description: The hollow, elongate, more or less cylindrical test is pale yellow-green with a faintly granular surface. The interior is empty. The length of the body is about 20μ. Two similar hollow spines without any partitions occur at the anterior end, joined at their bases and about equal to the body in length. The posterior spine is hollow, less than half the length of the body and widens broadly at the base to merge with the test.

Dimensions: Holotype: body 20μ long, 6μ wide; anterior spines 22μ long, 1.5μ wide near their bases; posterior spine 9μ long, 2μ wide at the base.

Occurrence: Buildwas Shales, sample BS/2 only, Harley Brook, Domas, Shropshire.

Comparisons: D. elongata differs from *D. trispinosa* in its more elongated body, the fusion of the anterior spines at the base, the broader posterior spine and the distinctly granular body surface.

PLATE 1

1, 9 *Deunffia furcata* Downie, n. sp.
Figure 1 shows the internal cavity of the spine divided into compartments, × ca. 1900; figure 9, holotype, × 1000.

2 *Deunffia ramusculosa* Downie, n. sp.
Holotype, × ca. 1900.

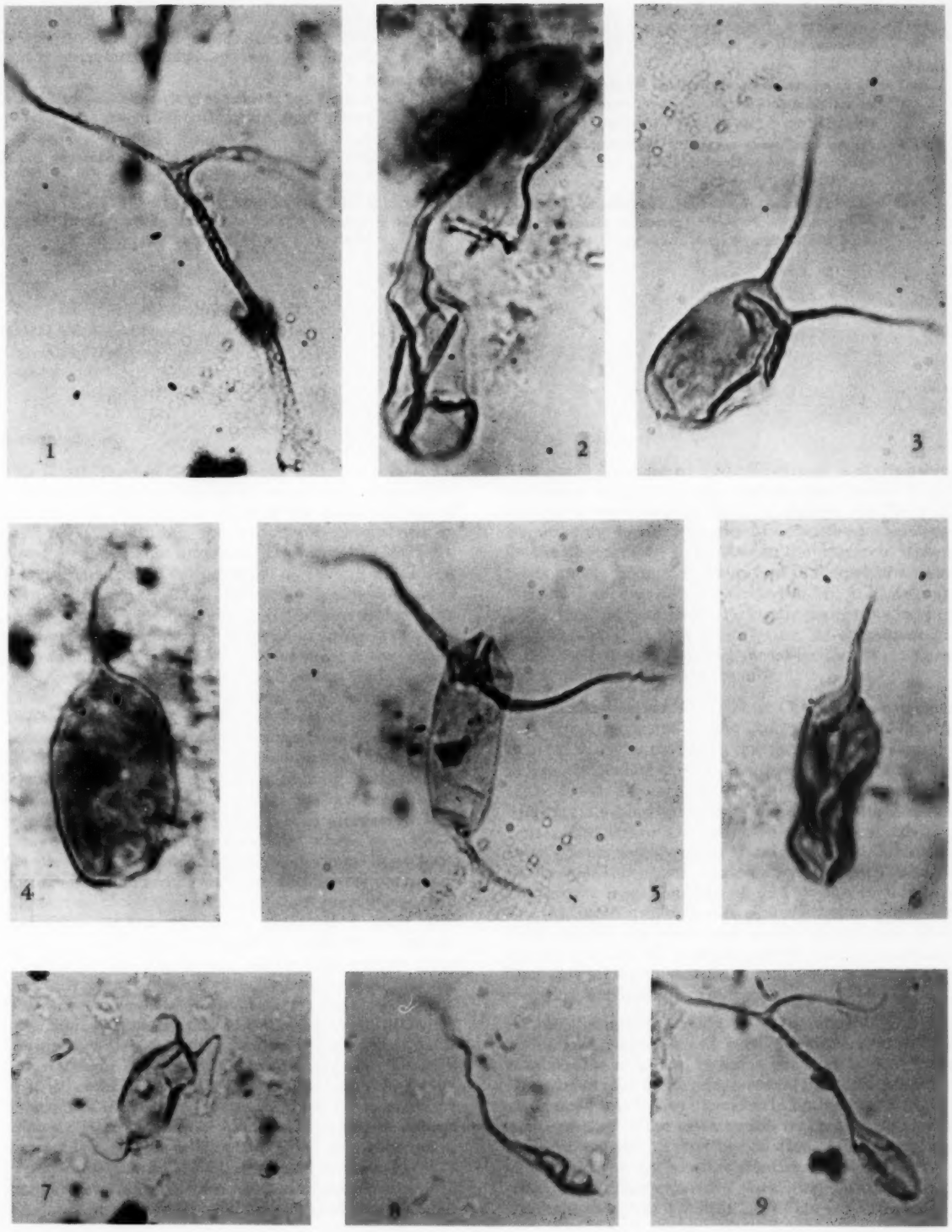
3 *Domasia bispinosa* Downie, n. sp.
Holotype, × ca. 1900.

4, 6 *Deunffia brevispinosa* Downie, n. sp.
Figure 4 with a relatively undeformed body, × 1900; figure 6, holotype, × ca. 1900.

5 *Domasia elongata* Downie, n. sp.
Holotype, × ca. 1900.

7 *Domasia trispinosa* Downie, n. sp.
Holotype, × 1000.

8 *Deunffia monospinosa* Downie, n. sp.
Holotype, × 1000.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ABSTRACT: *Twenty-seven species of marine Ostracoda from British Lower Cretaceous rocks are figured and described. The new subgenus* Acrocythere *is defined, together with three new species, two new subspecies and one new name to replace a homonym. Eight species are left under nomenclatura aperta. Comparisons are made with Hauterivian and Barremian ostracode faunas of northern Europe.*

Marine Lower Cretaceous Ostracoda from Yorkshire, England

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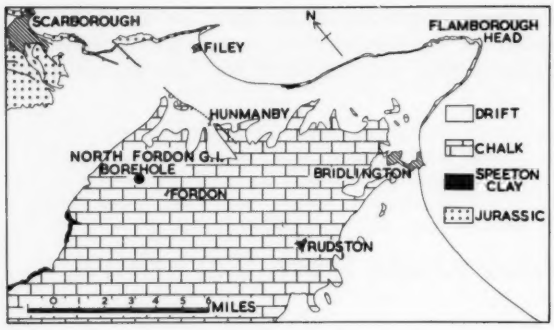
INTRODUCTION

The North Fordon G.1. borehole, put down in 1955, is one of a number of boreholes made to investigate the structure of the rocks underlying the chalk in part of east Yorkshire during the search for natural gas in Great Britain. This borehole (Lat. 45° 10′ 36·7″ N, Long. 0° 24′ 15·6″ W) lies three and a half miles west of the Hunmanby fault which has a downthrow of about 200 feet to the west, and fourteen miles west-north-west of Flamborough Head (text-fig. 1). After penetrating 235 feet of gravel, white and red chalk, the borehole proved 695 feet of Speeton Clay (Lower Cretaceous) before passing into Kimmeridge Clay. Drilling stopped 63 feet below the top of the latter at a depth of 993 feet. The maximum thickness of Speeton Clay recorded at outcrop on the coast is 296 feet and the Lower Cretaceous is generally held to thin inland (westwards) below the north facing chalk escarpment. Considerable interest thus attaches to the Lower Cretaceous in this borehole, where over twice the previously recorded maximum thickness at outcrop occurs well inland from the coast. In this area the Lower Cretaceous consists of a series of dark grey, black, and sometimes brown or bluish clays, shaly-clays and mudstones with many phosphatic nodules or "potato stones". In the Hauterivian part of the section there is usually a good deal of glauconite developed and the lower Hauterivian beds on the coast bear a considerable similarity to the "*Epistomina* schichten" of North Germany. Fifteen cores were taken in the Lower Cretaceous section of the borehole (text-fig. 2). Samples of these cores were taken at one foot intervals, giving 85 samples which were then examined for microfauna using standard techniques. While all the samples yielded foraminifera, which will be described in a subsequent paper, cores 1 to 5 (270–305 feet) and core 15 (917–923 feet) were devoid of ostracodes, and of the remaining 46 samples from the middle cores only 24 yielded ostracodes.

This paper is published by kind permission of the British Petroleum Company, Ltd., and the Gas Council. I wish to express my thanks to Dr. N. F. Falcon and Dr. F. E. Eames of the British Petroleum Company who arranged for the photography to be done in the research laboratories and to Messrs. D. Helm and E. Finch who carried this out. I am also deeply indebted to Mr. J. K. Ingham of the University of Hull who kindly made the drawings on which Plates 1 and 3 are based. All specimens are catalogued and deposited in the collections of the Geology Department, University of Hull.

The British marine Cretaceous Ostracoda have been very much neglected in the past. Apart from Bartenstein (1956), who covered a few forms only incidentally in a paper dealing predominantly with the foraminifera of the lower Tealby Clay (upper Hauterivian) of Lincolnshire, nothing has been published on British marine Lower Cretaceous Ostracoda in the present century. In this paper twenty-seven Hauterivian and Barremian species and subspecies are described, of which fourteen are known from deposits of similar age in northern Europe, three species and two subspecies are new, and eight species are described under *nomenclatura aperta* due to scarcity of material and/or bad preservation. One new subgenus is defined and a new name is proposed for one already preoccupied.

Within the middle section of the borehole the preservation and relative abundance of the ostracodes showed considerable variation. In the upper cores of this section (Barremian) the ostracodes were rare and fragmentary, while downwards they increased in both abundance and in the quality of the preservation reaching a maximum in cores 12 and 13 at 652–683 feet. The commonest genera proved to be *Dolocytheridea*, *Schuleridea*, *Protocythere* and *Haplocytheridea*, and the distribution of species is shown in Table 1.



TEXT-FIGURE 1

Map showing location of North Fordon G. 1. borehole.

SYSTEMATIC DESCRIPTIONS

Order Ostracoda Latreille
Suborder Platycopa G. O. Sars
Family Cytherellidae G. O. Sars
Genus Cytherella Jones, 1849

Cytherella pyriformis (Cornuel)
Plate 1, figure 9a–c; plate 4, figure 19a–b

Cythere amygdaloides var. *cylindracea* Cornuel, 1846, Soc. Géol. France, Mém., sér. 2, vol. 1, p. 198, pl. 7, fig. 10.

Cythere amygdaloides var. *pyriformis* Cornuel, 1846, Soc. Géol. France, Mém., sér. 2, vol. 1, p. 198, pl. 7, fig. 11.

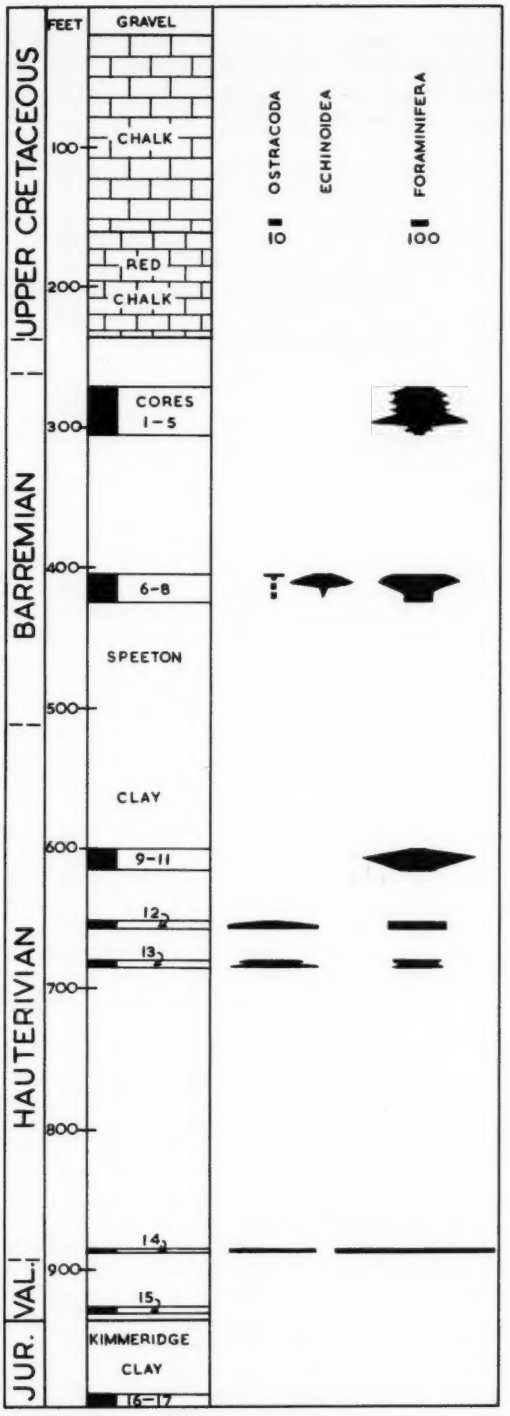
Cytherella pyriformis (Cornuel). – Deroo, 1956, Inst. Franç. Pétrole, Rev., vol. 11, p. 1508, pl. 1, figs. 1–3.

Dimensions of Fordon specimen: Length 0.64 mm.; height 0.35 mm.

Horizon: North Fordon G.1., 408 feet; Barremian.

Remarks: Only one carapace of this very distinctive species was found in the Fordon material. The right valve overlaps the left valve peripherally. The latter valve is highly characteristic, being oblong-oval in shape with the height about 53% of the length. The ventral margin of this valve is straight and parallel to that of the right valve, while the dorsal margin is gently concave upwards. Seen from the side, the height of the carapace is almost uniform but a little posterior of the mid-point it is slightly greater than elsewhere. In dorsal view the carapace shows the acute, flat-sided anterior taper which gives the species its pyriform shape and hence its specific name.

At Fordon this species is associated with *Cytherelloidea* sp. α, *Cythereis acuticostata* Triebel, and *Macrocypris* sp. γ. Cornuel's material and other French specimens are from the lower Barremian of Haute-Marne.

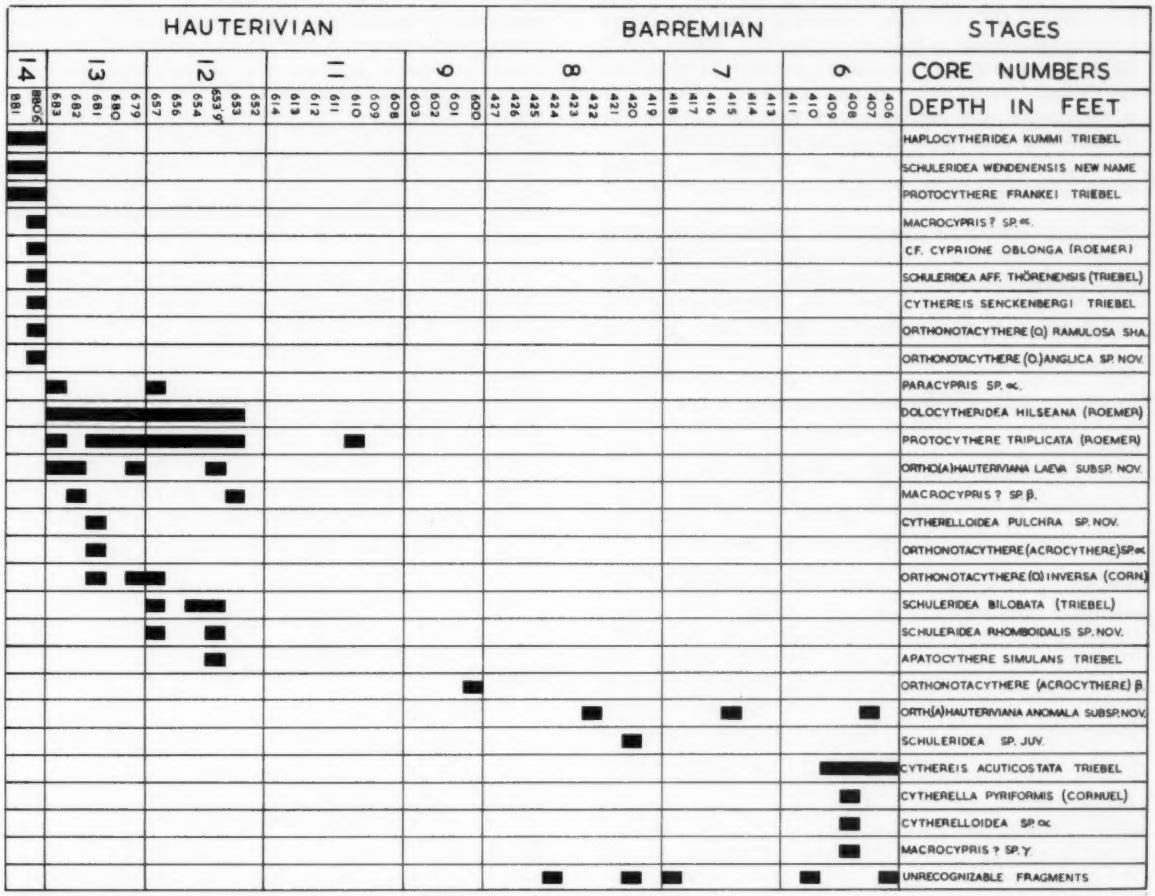


TEXT-FIGURE 2

Section showing position of cores and distribution of microfauna in the North Fordon G. 1. borehole.

TABLE 1

DISTRIBUTION OF OSTRACODA IN THE NORTH FORDON G. 1. BOREHOLE CORES.



Genus CYTHERELLOIDEA Alexander, 1929

Cytherelloidea pulchra Neale, **new species**

Plate 1, figure 10a–b; plate 4, figure 21a–b

Cytherelloidea ovata Weber. – BARTENSTEIN, 1956, Senckenbergiana Lethaea, vol. 31, pl. 3, fig. 85.

Non *Cytherelloidea ovata* WEBER, 1934, Niedersächs. Geol. Ver., vol. 26, pl. 8, fig. 4.

Holotype: One female left valve, HU.1.C.2.65.

Dimensions of holotype: Length 0.78 mm.; height 0.43 mm.

Horizon: North Fordon G.1., 681 feet, upper Hauterivian.

Material: Only one left valve was found in the Fordon material but this species is common in the C2 and C4 beds of the Speeton Clay at outcrop.

Diagnosis: A species with swollen ribs, one of which follows the anterior margin of the shell, while the other three run longitudinally. A very deep muscle pit occurs on the outside of the shell and is visible on the inside as a prominent node. This pit affects the run of the middle rib which, as a result, is indented on its dorsal side. The surface is finely reticulate.

Description: The swollen anterior rib is followed posteriorly by a deep, narrow sulcus which separates it from the longitudinal ribs. Ventrally this anterior rib fades into the ventral margin and does not run into the ventral longitudinal rib, being separated in the anterior part by a sharp sulcus. The ventral and median longitudinal ribs are more prominent than the dorsal one. The ventral one is sausage-shaped and follows the ventral margin fairly closely being separated from it by a well-defined sulcus. The median rib is separated

from the ventral rib by a very marked sulcus and has a graceful sinuous curve being concave upwards due to the emplacement of the deep muscle pit on the dorsal side in the middle. This large swollen rib expands posteriorly where it is joined to the similarly expanded ventral rib giving a pair of rather flat, large nodes. Dorsally there is a rather ill-defined rib which follows the dorsal margin and expands anteriorly where there is a vague connection with the anterior part of the median rib. The whole surface in well preserved specimens shows a beautiful delicate network or pitting which gives the species its name.

The form figured by Bartenstein as *Cytherelloidea ovata* Weber belongs here. This is from the upper Hauterivian of Lincolnshire and is quite distinct from the true *Cytherelloidea ovata* which has thin, sharp ribbing and which occurs lower down in the Hauterivian.

Cytherelloidea sp. α
Plate 1, figure 5

Type: One broken right valve, HU.1.C.2.40.

Dimensions: Length 0.44 mm.; height 0.26 mm.

Horizon: North Fordon G.1., 408 feet, Barremian.

Remarks: This specimen, besides being broken, is considerably smaller than the preceeding adult and is probably one of the pre-adult moults of a new species. It cannot be assigned to any described species and lacking any more material it is left under *nomenclatura aperta*. The valve is very flat and the ribs are thin and ill-defined. The surface is punctate showing a delicate mesh or net. The muscle node is well-defined on the inner surface. *Cytherelloidea* sp. α differs considerably from the preceeding species in that not only are the ribs much thinner and weaker but the run of the median longitudinal rib is not affected by the muscle pit and lies proportionally higher on the surface of the valve.

Family Cyprididae Baird
Subfamily Cypridinae G. W. Müller
Genus Paracypris G. O. Sars, 1866

Specimens belonging to *Paracypris* and *Macrocypris* are rare in the borehole material and are generally small and poorly preserved. All six specimens are figured and are distributed among four species. None of the species can be referred to known or figured species, and in view of the paucity of specimens and their poor preservation they are all left as *nomenclatura aperta*.

Paracypris sp. α
Plate 1, figure 4; plate 4, figure 6a–b

Horizon: North Fordon G.1., 657 and 683 feet, upper Hauterivian. Material consists of one left valve, HU.1. C.2.56., and one rather crushed carapace, HU.1. C.2.37.

Remarks: These two specimens are both 0.44 mm. long and are probably not adult forms. Shape, however, is one of the first features to show the adult characteristics (Neale, 1959) so that the characteristic humped appearance of the shell in side view is probably carried through into the adult. This hump is caused by the long straight, sloping anterior and posterior parts of the dorsal margin on either side of the short straight central portion. As a result the greatest height occurs almost at, or a little in front of, the mid-point of the valve. The anterior end is rounded in rather ellipsoidal fashion, the outline swinging away ventrally into the almost straight ventral margin which is slightly sinuous in the middle.

Comparisons with figured Cretaceous material are not close and in shape this form bears most resemblance to *Paracypris* cf. sp. *B* Schmidt, figured by Oertli (1957, pl. 1, figs. 19–22), which comes from the middle of the lower Kimmeridgian of borehole material from the Paris Basin. In the present species, however, the humping of the shell in side view is much more pronounced.

Family Bairdiidae G. O. Sars
Subfamily Macrocypridinae G. W. Müller
Genus Macrocypris G. S. Brady, 1867

Macrocypris ? sp. α
Plate 4, figure 5

Horizon: North Fordon G.1., 880 feet 6 inches, lower Hauterivian.

Only one specimen of this species exists in the form of a pyritised carapace 0.50 mm. long. HU.1. C.2 55.

In shape this species resembles *Paracypris* sp. α except that the ventral margin swings dorsally in the posterior third of the shell so that it is markedly convex and the pointed posterior end lies about one-third of the height above the ventral margin. Due to poor preservation it is impossible to ascertain any of the internal details. The right valve appears to overlap the left and on these grounds the shell is referred somewhat doubtfully to *Macrocypris*.

Macrocypris ? sp. β
Plate 1, figure 1–2

Horizon: North Fordon G.1., 653 and 682 feet, upper Hauterivian.

Material: One carapace, HU.1.C.2.36, from 682 feet. It is 0.45 mm. long, and a rather larger broken left valve, HU.1.C.2.39 from 653 feet which is filled with pyrite and is 0.48+ mm. long.

The right valve overlaps the left at the dorsal margin and for this reason the specimens are referred to *Macrocypris*, although on shape alone they are more akin to *Paracypris*. When seen in side view, the greatest height occurs one-third of the way from the anterior end. The

dorsal margin consists of a short straight portion which slopes anteriorly, a larger median straight part sloping gently posteriorly, and a posterior straight section which slopes more steeply to meet the ventral margin at a point. The anterior is gently rounded, and posteriorly the shell ends in a point. The ventral margin is markedly concave.

This differs from any described species of *Macrocypris* and in shape is much higher in proportion to the length than is generally the case with this genus, so that its assignment here must be regarded with caution. Unfortunately, preservation precludes a study of the muscle scars and other structural features.

Macrocypris ? sp. γ
Plate 1, figure 3

Horizon: North Fordon G.1., 408 feet, Barremian.

Only one pyritised left valve, HU.1.C.2.20, 0.39 mm. long, was found, and no internal details are visible. In side view the shape is very elongated, height only amounting to 40% of the length, and the dorsal and ventral margins are relatively straight and almost parallel. The anterior end is ellipsoidally rounded. The posterior part of the dorsal margin is straight and slopes down to meet the ventral margin giving a somewhat truncated appearence posteriorly.

Again little comparison can be made with known species but there is some slight resemblence to the *Cytherina modesta* figured by Reuss 1850 from the Kreidemergel of Lemberg, Poland.

Family CYTHERIDEIDAE G. O. Sars
Subfamily CYTHERIDEINAE G. O. Sars

Genus **Apatocythere** Triebel, 1940

From the general form of the shell, the fan-like arrangement of the numerous radial pore canals, and the presence of a marked accommodation groove, it is obvious that this genus is very closely related to *Schuleridea*. The essential difference lies in the anterior pessular tooth and posterior, elongate non-crenulate cusp in the right valve.

Apatocythere simulans Triebel, 1940
Plate 2, figures 3, 9

Apatocythere simulans TRIEBEL 1940, Senckenbergiana Lethaea, vol. 35, p. 170, pl. 1, figs. 14–19; pl. 9, figs. 102–103.

Horizon: North Fordon G.1., 653 feet 9 inches, upper Hauterivian.

Remarks: This species is represented by one female right valve and one female carapace in the Fordon material. The hinge structure comes out well and the specimens agree exactly with Triebel's description and figures to which there is nothing to add. The German specimens come from the upper Hauterivian and lower Barremian.

Genus DOLOCYTHERIDEA Triebel, 1938

Dolocytheridea hilseana (Roemer)

Plate 2, figures 13, 19, 20; text-figures 3–4

Cytherina hilseana ROEMER, 1841, Die Versteinerungen des norddeutschen Kreidegebirges, Hannover, p. 104, pl. 16, fig. 17.

Cythere amygdaloides CORNUEL, 1846, Soc. Géol. France, Mém., ser. 2, vol. 1, mém. 5, p. 197, pl. 7, figs. 1–9; 1848, ibid., vol. 3, p. 242, pl. 1, fig. 1.

Cythere amygdaloides var. *lata* CORNUEL, 1848, ibid., vol. 3, p. 242, pl. 1, figs. 2–4.

Cythere amygdaloides var. *punctulata* CORNUEL, 1848, ibid., vol. 3, p. 242, pl. 1, figs. 5–6.

Cytheridea hilseana (Roemer). – WEBER, 1934, Niedersächs. Geol. Ver., Jahrb., vol. 26, p. 143, pl. 8, fig. 2.

Cytheridea hilseana (Roemer). – EICHENBERG, 1935, Oelu. Kohle, vol. 2, p. 412, pl. 14, fig. 19.

Cytheridea (*Dolocytheridea*) *hilseana* (Roemer). – TRIEBEL, 1938, Senckenbergiana, vol. 20, pp. 495–498, pl. 4, figs. 68–79; pl. 6, fig. 90.

Dolocytheridea hilseana (Roemer). – STCHÉPINSKY, 1954, Géol. Soc. France, Bull., ser. 6, vol. 4, p. 490, pl. 22, figs. 11, 12, text-plate 1, fig. 8.

Dolocytheridea hilseana (Roemer). – DEROO, 1956, Inst. Franç. Pétrole, Rev., vol. 11, p. 1511, pl. 2, figs. 22–25.

Dolocytheridea hilseana (Roemer). – OERTLI, 1958, ibid., vol. 12, pl. 4, figs. 83, 84.

Non *Cythere amygdaloides* var. *cylindracea* CORNUEL, 1846, Soc. Géol. France, Mém., sér. 2, vol. 1, mém. 5, p. 198, pl. 7, fig. 10.

Cythere amygdaloides var. *pyriformis* CORNUEL, 1846, ibid., p. 198, pl. 7, fig. 11.

Cythere amygdaloides var. *arcuata* CORNUEL, 1846, ibid., p. 198,

Cythere amygdaloides var. *brevis* CORNUEL, 1846, ibid., vol. 3, p. 199, pl. 7, fig. 12.

Pontocypris (*Cytherina*) *hilseana* (Roemer). – EGGER, 1910, Naturw. Ver. Regensburg, Ber., vol. 12, p. 93, pl. 6, figs. 9–11.

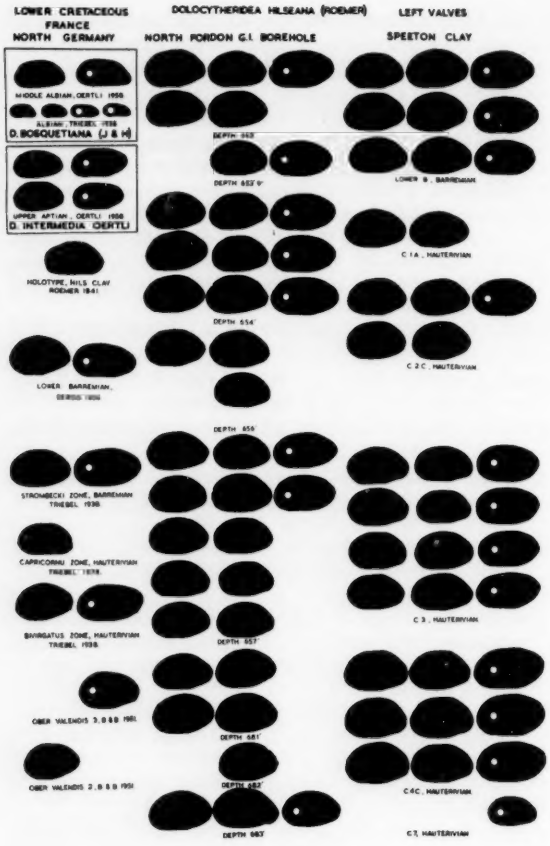
Cytheridea amygdaloides (Cornuel). – ALEXANDER, 1929, Texas Univ. Bull., no. 2907, p. 69, pl. 4, figs. 16–17.

Cytheridea (*Haplocytheridea*) *punctulata* (Cornuel). – TRIEBEL, 1938, Senckenbergiana, vol. 20, p. 483, pl. 2, figs. 40–41.

Cuneocythere amygdaloides (Cornuel) – SHARAPOVA, 1939, All-Union Petrol. Sci. Res. Geol. Expl. Inst., (VNIGRI) Trans. ser. A, no. 126, p. 45, pl. 3, figs. 39–41.

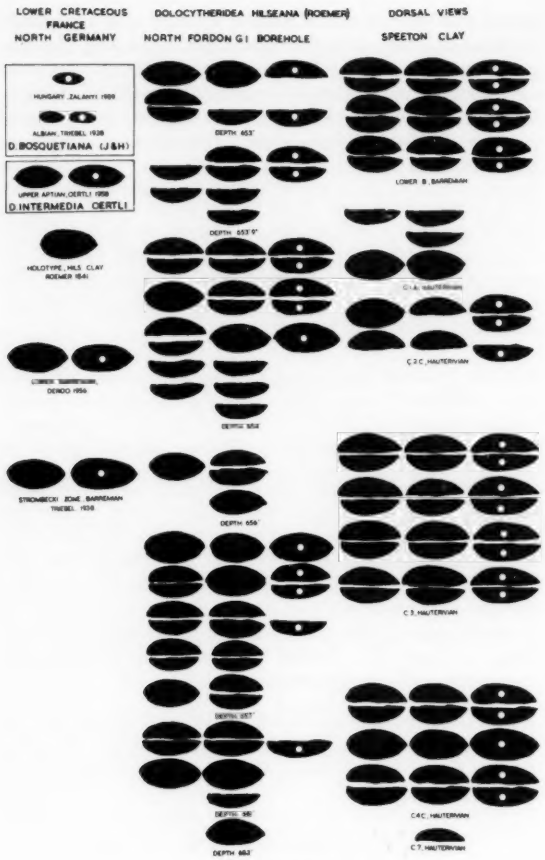
Horizons: North Fordon G.1. at depths of 653, 653 feet 9 inches, 654, 656, 657, 679, 680, 681, 682, 683 feet, upper Hauterivian.

Remarks: This is the commonest ostracode in the Fordon borehole and the species has been adequately figured and described by Triebel, Stchépinsky and others. Sexual dimorphism is pronounced, the male being more elongated and parallel-sided than the female. Shape shows some variation but the variation within a single community is often as great as that between communities widely separated in space and time. Text-figures 3 and 4 show the variations in shape in side and dorsal view in material from German and French localities, based on published figures which have been



TEXT-FIGURE 3

Variations in shape of the left valve of *Dolocytheridea hilseana* (Roemer) seen in side view. Males are marked with a white spot.



TEXT-FIGURE 4

Variations in shape of *Dolocytheridea hilseana* (Roemer) seen in dorsal view. Males are marked with a white spot.

reproduced to a standard size of magnification, together with the variations in British material from the Fordon borehole and the Speeton Clay at outcrop, based on camera lucida drawings at the same magnification. The species is essentially Hauterivian and Barremian.

Recently, Oertli (1958) described a new species, *Dolocytheridea intermedia*, from the Aptian of France. This occurs in a stratigraphically intermediate position between *D. hilseana* below and the typically Albian *D. bosquetiana* Jones and Hinde above. *D. intermedia* differs from *D. hilseana* in the anterior marginal zone and in the greater elongation and somewhat simpler hinge structure.

Genus HAPLOCYTHERIDEA Stephenson, 1936

Haplocytheridea kummi Triebel, 1938

Plate 1, figure 7; plate 2, figures 11, 15, 17, 22

Cytheridea (*Haplocytheridea*) *kummi* TRIEBEL 1938, Senckenbergiana, vol. 20, p. 486–489, pl. 3, figs. 48–52; pl. 6, fig. 87. – BARTENSTEIN AND BRAND, 1951, Senck. Naturf. Ges., Abh., no. 485, p. 331, pl. 19A, figs. 62–65, 71, 72.

Horizons: North Fordon G.1, 880 feet 6 inches to 881 feet, lower Hauterivian.

Generic position: Triebel referred this species to the subgenus *Haplocytheridea* but Howe and Laurencich (1958,

p. 354) regard the generic position as uncertain. This is apparently due to the supposed presence of an accommodation groove. The material available shows that there is no accommodation groove present in this form and that the right valve possesses the elongate terminal crenulate cusps, separated by a crenulate median bar characteristic of *Haplocytheridea*. This is reflected in the left valve which overlaps the right but does not develop an accommodation groove. The hinge elements show more differentiation than in *Haplocytheridea montgomeryensis* Howe and Chambers, also the shape differs fairly considerably.

In this latter respect *Haplocytheridea kummi* is more closely akin to such species as *Palaeocytheridea observata* (Sharapova) figured by Liubimova (1955, p. 56, pl. 3, fig. 2) from the Neocomian of the Ural-Emba region. Some confusion has arisen, however, in the interpretation of the genus *Palaeocytheridea*. This was originally defined by Mandelstam (1947, p. 245) with the middle Jurassic *P. bakirovi* as the genotype, a species with crenulate terminal sockets separated by a median bar in the left valve and lacking an accommodation groove. Liubimova (1955, p. 35) later gave the genotype as *Eucythere denticulata* Sharapova, 1937. The reason for this change is obscure but it is invalid under the International Rules, since *Eucythere denticulata* is not one of the species covered or even mentioned by Mandelstam in his original description of *Palaeocytheridea*. Besides differing considerably in shape and ornament, *E. denticulata* also differs from *P. bakirovi* in possessing a marked accommodation groove in the left valve, and on the grounds of hinge structure has been referred to *Asciocythere* Swain, 1952 by Howe and Laurencich (1952, p. 442). *Palaeocytheridea observata* has also been placed in *Asciocythere* by these authors (*op. cit.* p. 60) although this species lacks the accommodation groove in the left valve which is one of the features of the genotype (*Bythocypris rotundus* Vanderpool). The presence or absence of an accommodation groove is related to the mechanics of the valve opening, however, and is probably not of prime importance as a generic differentiating character. The only essential difference in hinge structure between *Palaeocytheridea observata* and *Haplocytheridea kummi* lies in the fact that the former possesses a median bar in the left valve, while the latter possesses a median groove in the same valve; they would undoubtedly be referred to the same genus on all other grounds. Reversal of hinge structure which has been noted in one species of *Cytheridea* (Alexander and Alexander, 1933) may perhaps have some bearing here.

A careful re-appraisal of the relative importance of the features within the hinge and the hinge structure as a whole is needed, particularly in respect to the taxonomy of the *Cytheridea* group where considerable uncertainty exists. It would appear that the nature of the marginal areas and shape form a far sounder basis for generic distinctions (Malkin, 1953) while the hinge structure is subject to considerable variation (Beroušek, 1952, Skogsberg, 1928, *et al.*). Until such a study is undertaken it would be premature to refer *H. kummi* to the *Palaeocytheridea observata* group, notwithstanding the obviously close relationships of the two species.

As shown above, the hinge of the Fordon species corresponds with *Haplocytheridea* and it is here referred to that genus, although it may later be advisable to place it elsewhere on the grounds of shape. It seems as though it may eventually become necessary to split the species assigned to *Palaeocytheridea* by Liubimova also and place some of them, such as *P. observata*, in genera other than *Asciocythere*.

Description: There is little to add to Triebel's description (1938*b*, pp. 486–489). As noted above there is no accommodation groove in the left valve. The crenulations of the cusps are well differentiated in the terminal areas of the hinge and number about seven both anteriorly and posteriorly. The median bar in the right valve and the corresponding groove in the left valve are crenulate and narrow. The dorsal margin of the left valve is markedly "crenulate" although "granulate" would perhaps be a better term. The muscle scars consist of a vertical row of four, the middle two of which are kidney shaped, the dorsal and ventral ones being more equidimensional. Anteriorly there are three mandibular scars, one main heartshaped scar, a somewhat oblong scar closely adjoining the latter postero-ventrally and a minute circular anterodorsal scar.

The normal pore canals are large, and sparsely distributed and the radial pore canals, which are straight, are also not numerous. Anteriorly, the radial pore canals are difficult to ascertain at their inner margins, as is the line of concrescence, since these areas of the shell did not clear satisfactorily when the shells were immersed in benzyl alcohol. The inner lamella appeared to merge into the body of the shell and the radial pore canals appeared to be straight as is the case posteriorly. As a result, the anterior structures shown in plate 1, figure 7 are somewhat tentative. The right valve, which is not figured here, corresponds with that figured by Triebel (1938*b*, pl. 6, fig. 87).

Bartenstein and Brand (1951, p. 331) have recorded this species from Ober Valendis 2 and Ober Valendis 4 in North Germany, while Triebel's material all came from the lower Hauterivian *noricus*-schichten.

Genus SCHULERIDEA Swartz and Swain, 1946

Schuleridea bilobata (Triebel)
Plate 2, figures 16a–b, 21

Cytheridea (*Haplocytheridea*) *bilobata* TRIEBEL, 1938, Senckenbergiana, vol. 20, p. 479, pl. 1, figs. 17–20.

Schuleridea bilobata (Triebel). – TRIEBEL, 1954, Senckenbergiana Lethaea, vol. 35, p. 6, pl. 4, figs. 28, 29.

Haplocytheridea bilobata (Triebel). – STCHÉPINSKY, 1954, Geol.Soc. France, Bull., sér. 6, vol. 4, p. 486, text-plate 2, fig. 12.

Horizons: North Fordon G.1, 653 feet 9 inches, 654 and 657 feet, upper Hauterivian.

Remarks: The males of this species are quite characteristic in having a postero-ventral lobe or lappet which tends to form a small node giving the shell a distinctive outline in side view. Both males and females occur in the Fordon material, the females being shorter in proportion to the height than the males. This species is recorded from the Hauterivian and Barremian of North Germany.

Schuleridea rhomboidalis Neale, **new species**
Plate 2, figures 1a–b, 2, 5, 7, 8

Holotype: Female carapace, HU.1.C.2.99.

Horizon: North Fordon G.1, 653 feet 9 inches, 657 feet, upper Hauterivian.

Material: Three female carapaces, three female and two male right valves, one female and two male left valves, five juveniles, four fragments.

Dimensions of holotype: Length 0.75 mm.; height 0.52 mm.; breadth 0.42 mm.; proportion of height to length, 70%.

Diagnosis: A rather rhomboidally-shaped shell in the female with the dorsal margin strongly arched, reaching its greatest height at about one-third of the distance from the anterior end. Posterior to this, the dorsal margin runs in a straight line to the blunt postero-dorsal angle where it meets the straight section which forms the posterior margin of the shell and gives it its somewhat truncated appearance. There is a prominent eye-tubercle defined ventrally by a small sulcus. The ventral margin is convex and runs to join the truncated posterior margin in a blunt point. The surface is evenly covered with a moderate number of well developed normal pore canals which appear as lucid spots on the carapaces and form a small pit at the surface. The anterior radial pore canals are numerous and show the usual fan-like arrangement anteriorly. In dorsal view, the carapace is inflated in the mid-region reaching its greatest width a little behind the mid-point.

Affinities and differences: S. rhomboidalis differs from all other described species of *Schuleridea* in shape, particularly in the shape of the posterior part of the carapace as seen from the side. This latter ends in a rounded point which is very conspicuous in the females where it lies about one third of the height above the ventral margin (pl. 2, figs. 1a, 2, 5), and is rather less conspicuous in the males where it is lower, lying about one-quarter of the length above the ventral margin (pl. 2, figs. 7, 8.). The only species which shows any resemblance in shape of the posterior part of the shell appears to be *Schuleridea? oliverensis* (Alexander) from the American Kiamichi formation, but in this species the height is much greater in proportion to the length and it is more triangulate dorsally. At first sight confusion is possible with *Apatocythere simulans* Triebel which occurs at the same horizon (pl. 2, fig. 3) but this latter species is more evenly rounded and the inflation just posterior of the middle is not so marked. When visible the hinge structure immediately resolves any difficulty. In dealing with the Fordon material it was found possible to check the hinge structure in closed carapaces by immersion in suitable clearing liquids.

Derivation of name: In the female the ventral margin of the shell swings away towards the posterior point from a postion about half way from the anterior end and gives the female a characteristic rhomboidal appearance in side view. The dorsal view is also somewhat rhomboidal, hence the specific name.

Schuleridea aff. **thorenensis** (Triebel)
Plate 2, figures 4, 6

Cytheridea (*Haplocytheridea*) aff. *thorenensis* Triebel, 1938, Senckenbergiana, vol. 20, pl. 2, figs. 30–34.

Cytheridea (*Haplocytheridea*) cf. *thorenensis* Triebel. – Bartenstein and Brand, 1951, Senck. Naturf. Ges., Abh., no. 485, p. 331, pl. 14a, fig. 36; pl. 15d, fig. 43; pl. 16, figs. 63–65; pl. 17a, figs. 22, 23; pl. 18, figs. 100–105, 108.

Cytheridea (*Haplocytheridea*) *thorenensis* Triebel. – Bartenstein, 1956, Senckenbergiana Lethaea, vol. 37, p. 530, pl. 3, figs. 82–84.

Horizon: North Fordon G.1, 880 feet 6 inches, lower Hauterivian.

Remarks: This form is close to the true *S. thorenensis* but differs in the rather less arched dorsal margin and in the posterior part of the shell which ends in a blunt point showing a characteristic outline in side view of the left valve. Sexual dimorphism is pronounced. A new name would seem to be desirable for this form and should preferably come from the German workers and be based on the original material which needs fuller description, together with a full assessment of the range of variation. The specimens figured here do not show the characteristic shape of the posterior end in side view particularly well, and in this respect are closer to the true *S. thorenensis* than, for example, those figured by Bartenstein, 1956.

The material of Triebel (1938) and Bartenstein (1956) came from the Hauterivian. That of Bartenstein and Brand (1951) came from the upper Valanginian and seems referable, at least in part, to this form.

Schuleridea wendensis Neale, **new name**
Plate 2, figures 10, 12

Cytheridea (*Haplocytheridea*) *punctulata* (Cornuel). – Triebel, 1938, Senckenbergiana, vol. 20, p. 483, pl. 2, figs. 40, 41.

Non *Cythere amygdaloides* var. *punctulata* Cornuel, 1848, Soc. Geol. France, Mém., sér. 2, vol. 3, p. 242, pl. 3, figs. 5, 6.

Horizons: North Fordon G.1, 880 feet 6 inches, 881 feet, lower Hauterivian.

Stchépinsky, working with Cornuel's type material, has shown that Cornuel's var. *punctulata* belongs to *Dolocytheridea hilseana* and not to *Schuleridea*. This is accepted

by Deroo (1956, p. 154) who notes that a new name is needed. This is fortunate, since there is also a *Schuleridea punctatula* (Roemer). Triebel's species is here renamed *S. wendenensis* after the locality from which Triebel obtained his specimens.

This species is characterised by the large, deep, round pits on the surface of the shell which are formed by the ends of the normal pore canals. These pits lie in parallel rows along the anterior and ventral margins. In side view, the shell is elongated in the male with the dorsal and ventral margins of the right valve more or less parallel, the greatest height being reached at the cardinal angle about one-third of the way from the anterior end. The dorsal margin behind the cardinal angle is straight until a rounded angle leads into the smaller, rounded posterior end. In the left valve the dorsal margin is smoothly arched. Eye-tubercles or nodes are present. In dorsal view the greatest width occurs about the middle of the length and the posterior end is more inflated and rounded than the anterior which tapers gently to a blunt point as shown in plate 2, figure 16b. Sexual dimorphism is pronounced, the males being more elongated than the females.

Family CYTHERIDAE Baird
Subfamily CYTHERINAE Dana
Genus PROTOCYTHERE Triebel, 1938

Protocythere frankei Triebel
Plate 2, figure 18a–b

Protocythere frankei TRIEBEL, 1938, Senckenbergiana, vol. 20, p. 192, pl. 2, figs. 23–26. – DEROO, 1956, Inst. Franç. Pétrole, Rev., vol. 11, p. 1513.

Horizon: North Fordon G.1., 880 feet 6 inches, 881 feet, lower Hauterivian.

Remarks: The specimens show the characteristic features of the species. The swollen anterior rim is seen well in dorsal view (pl. 2, fig. 18a) where it is sharply marked off from the rest of the carapace by a prominent sulcus. In side view, the marginal denticulations are very well developed both anteriorly and on the postero-ventral edge. The whole carapace is densely punctate and the longitudinal lines of punctae are well seen on the ventral surface. Triebel's specimens are from the Hauterivian *noricus*-schichten of North Germany while Deroo similarly records this species from the lower Hauterivian of Yonne and Haute-Marne.

Protocythere triplicata (Roemer)
Plate 2, figures 14, 23, 24

Cytherina triplicata ROEMER, 1841, Die Versteinerungen des norddeutschen Kreidegebirges, Hannover, p. 104, pl. 16, fig. 16.

Cythere triplicata (Roemer). – WEBER, 1934, Niedersächs. Geol. Ver., Jahrb., vol. 26, p. 140, pl. 8, fig. 1; pl. 9, fig. 5. – EICHENBERG, 1935, Oel und Kohle, vol. 11, no. 23, p. 412, pl. 14, fig. 17.

Protocythere triplicata (Roemer). – TRIEBEL, 1938, Senckenbergiana, vol. 20, p. 182, pl. 1, figs. 1–5; pl. 3, figs. 33–37. – STCHÉPINSKY, 1954, Géol. Soc. France, Bull., sér. 6, vol. 4, p. 492, text-pl. 3, fig. 19. – DEROO, 1956, Inst. Franç. Pétrole, Rev., vol. 11, p. 1513, pl. 3, figs. 37–39. – BARTENSTEIN, 1956, Senckenbergiana Lethaea, vol. 37, p. 530, pl. 3, figs. 70–72.

?*Cytherettina triplicata* (Roemer). – MANDELSTAM, 1956, All-Union Sci. Res. Geol. Inst., Trans., no. 12, p. 134, fig. 47.

Non *Cythereis triplicata* (Roemer). – JONES AND HINDE 1890, Palaeontogr. Soc. London, Monogr., vol. 38, p. 19, pl. 1, figs. 56–61.

Non *Cythere triplicata* (Roemer). – ALEXANDER, 1929, Texas Univ. Bull., no. 2907, p. 79, pl. 6, fig. 8.

Horizons: North Fordon G.1., occurs at 610, 653, 653 feet 9 inches, 654, 656, 657, 679, 680, 681, 683 feet.

There is nothing to add to the description of this species which is already well described in the literature. Formerly held to range throughout the Neocomian its range has been gradually restricted until it is now generally regarded as Hauterivian and Barremian. Deroo (1956, p. 1513), however, shows that it is essentially Hauterivian, the Barremian form being referable to *P. auriculata* (Cornuel). The present species is far more common and more widely distributed in the Fordon borehole than *P. frankei*.

Subfamily LOXOCONCHINAE G. O. Sars
Genus ORTHONOTACYTHERE Alexander, 1933

A number of species which differ somewhat from the genotype have been included in this genus in the past. The genus is here split into two subgenera.

Orthonotacythere, sensu stricto, contains forms close to the genotype, *Cytheridea* (?) *hannai* Israelsky, while the new subgenus *Acrocythere* is used to accommodate forms such as *Orthonotacythere hauteriviana* Bartenstein which, while having the typical *Orthonotacythere* hinge and shell structure differ from *Orthonotacythere s. s.* in shape and show a dominant costate or reticulate ornament.

Subgenus **Orthonotacythere**, *sensu stricto*

Subgenotype: Orthonotacythere hannai (Israelsky), 1929.

Diagnosis: Orthonotacythere which show the typical shape in side view, the ventral margin swinging markedly dorsally in the posterior part of the shell so that the posterior point lies well above the mid-line of the valve. Ornament is dominantly tuberculate and a sulcus is usually developed.

Alexander (1933, p. 200) has fully described the internal characters of the subgenotype and no further description is given here.

Adult specimens in the Fordon borehole were usually fragmentary so the figured material is drawn mainly from specimens of the penultimate instar which were usually well preserved.

Orthonotacythere (Orthonotacythere) anglica Neale, **new species**

Plate 3, figures 2a–b, 6; plate 4, figures 7, 8, 9, 12, 16

Syntypes: Male and female left valves. Instar 8, HU.1.C.2.29, HU.1.C.2.33.

Dimensions: Adult, HU.1.C.2.49, male, right valve: length 0.74 mm.; height 0.34 mm.; proportion of height to length, 46%. Instar 8, HU.1.C.2.33, female, left valve: length, 0.45 mm.; height 0.30 mm.; proportion of height to length 66%.

Other material: Ten valves and fifteen fragments from 880 feet 6 inches.

Horizon: North Fordon G.1, 880 feet 6 inches, lower Hauterivian.

Diagnosis: A species of *Orthonotacythere* with a prominent postero-dorsal tubercle; wide, shallow, vertical, median sulcus subdivided by a shallow ridge; antero-median tubercle and a ventral complex of four or five fine longitudinal ribs. These tend to form a complex of small tubercles in the antero-ventral part of the valve.

Description: There is little to add to the diagnosis except to refer to the figures. The four small marginal denticulations at the anterior margin are a constant feature of the available material (pl. 4 figs. 7, 8, 12), although similar denticulations occur in a number of species of *Orthonotacythere*. This species is closely related to the stratigraphically higher *O. inversa*. It differs principally in lacking the antero-dorsal tubercle which so markedly affects the outline of the latter species.

Orthonotacythere (Orthonotacythere) inversa (Cornuel)

Plate 3, figures 1a–b; 5a–b; plate 4, figure 11

Cythere inversa Cornuel 1848, Soc. Géol. France, Mém., sér. 2, vol. 3, p. 244, pl. 1, figs. 12–14.

Orthonotacythere inversa (Cornuel). – Stchépinsky, 1954, Géol. Soc. France, Bull., sér. 6, vol. 4, p. 496, text-pl. 4, fig. 26a–d; pl. 22, fig. 1. – Deroo, 1956, Inst. Franç. Pétrole, Rev., vol. 11, p. 1516, pl. 3, figs. 46–48.

Dimensions: Instar 8, HU.1.C.2.38, male, left valve: length, 0.49 mm.; height 0.27 mm.; proportion of height to length, 55%; instar 8, HU.1.C.2.28, left valve: length, 0.52 mm.; height 0.34 mm.; proportion of height to length, 65%.

Horizons: North Fordon G.1. at 657, 679, 681 feet.

Remarks: This species has been poorly figured in the past and some difficulty arises in its interpretation. Stchépinsky worked with Cornuel's type material and as far as can be seen the Fordon material agrees well in the pattern of tuberculation and ornament with the type. There is some difference in the specimen figured from Fordon (pl.3, fig. 5a) in that it appears to be somewhat more sharply pointed posteriorly than the type but this is within the limits of variation of the material. One of the most characteristic features lies in the two dorsal tubercles which break up the dorsal outline of the shell and which is well seen in both the British and French material. The antero-median tubercle although not mentioned by Stchépinsky appears in his figure and seems to merge into the dorsal tubercle or be connected by a short ridge as in the Fordon specimens (pl. 3, fig. 1a, rather than pl. 3, fig. 5a). Stchépinsky's figure also shows an antero-ventral "bulge" or plexus of small tubercles shown in the Fordon specimens and referred to in the description of the preceding species which appears to be a lower Hauterivian precursor of *O. inversa*. In certain lights the reticulation of the shell may be made out, but is not shown in the drawings. It is not prominent in the Fordon specimens due to their preservation but it agrees with the figures of Stchépinsky and Deroo.

Cornuel's type comes from the lower Barremian but Deroo has found this species as low as the lower Hauterivian. The Fordon specimens occur at least 200 feet above the base of the Hauterivian.

Orthonotacythere (Orthonotacythere) ramulosa Sharapova, 1939

Plate 3, figures 8a–b, 13a–b; plate 4, figures 15, 18

Cytheropteron cf. *pedatum* var. *salebrosa* Jones and Hinde. – Weber, 1934, Niedersächs. Geol. Ver. Jahrb., vol. 26, pl. 9, figs. 1a, b.

Non *Cytheropteron pedatum* (Marsson) var. *salebrosa* Jones and Hinde, 1890, Palaeontogr. Soc. London, Monogr., vol. 38, p. 39, pl. 3, fig. 8; pl. 4, figs. 32–35.

Orthonotacythere ramulosa Sharapova, 1939, All-Union Petrol. Sci. Res. Geol. Expl. Inst., ser. A, no. 126, p. 29, pl. 3, fig. 34, (?Instar 7 male, right valve, *not* left valve). – Liubimova, 1955, All-Union Petrol. Sci. Res. Geol. Expl. Inst., n. s., no. 84, p. 93, pl. 10, fig. 5, (Instar 8, female left valve).

Dimensions: Adult male carapace from Speeton Clay C3, Hauterivian: length 0.71 mm.; height 0.38 mm.; width overall 0.51; less spines 0.31 mm.

Horizons: North Fordon G.1, at 880 feet 6 inches Speeton Clay C2B, C3, Hauterivian.

Description: Typical *Orthonotacythere* shape in side view with straight or slightly concave dorsal margin and subparallel ventral margin; the anterior margin is rounded; the ventral margin swings dorsally in the posterior third of its run to give the characteristic pointed posterior end, the point lying well above the mid-line. The shell possesses a deep, vertical sulcus which lies just anterior to the mid-point of the shell and runs from the dorsal margin to terminate between the two median ventral spines without quite reaching the ventral margin. The sulcus contains a small spine just dorsal of the mid-line which breaks it up into a short shallow anterior portion and a deeper, larger and more prominent posterior portion. Immediately behind the sulcus and about a quarter of the height down from the dorsal margin lies a large flat spine.

The remaining eight spines form the most characteristic feature of the adult and are distributed round the periphery of the shell. Two lie respectively antero-dorsally and postero-dorsally, a further two lie a little ventrally of these, while a curved row of four follows the ventral margin. Of the latter the postero-median spine is by far the most prominent on the whole shell. In ventral view all the ventral spines are coarse and thick being flattened and oblong-shaped and even tending to expand at their extremities. The largest spine noted above is 0.104 mm. long and 0.070 mm. broad. In ventral view the carapace has a biconvex outline which is broken up by the spines to give a "cog-wheel" effect. The ventral surface is flattened and has a prominent, sinuous, longitudinal rib on each side of the contact margin of the valves, running midway between this and the margin. In the adult the shell is thick and solid but in the earlier instars it shows a very marked reticulation.

The Fordon specimen (pl. 3, fig. 13a–b) consists of a female left valve belonging to the penultimate instar and reaching a length of 0.52 mm. Its ornament corresponds closely with the adult form from the C3 beds of the Speeton Clay, all the elements being present, the only difference being in the lesser development of the two antero-ventral spines. Sexual dimorphism is pronounced, the males being more elongated than the females. In the males the height is 53% of the length; in the females, the height is 60% of the length. The adult form corresponds closely to the specimen figured from the Hauterivian of Wenden (Weber, pl. 9, fig. 1a–b) and is certainly not *Cytheropteron pedatum* (Marsson), var. *salebrosa* Jones and Hinde. It appears to be conspecific with *O. ramulosa* Sharapova. The female left valve from the Neocomian of the Obschii Syrt figured by Liubimova (1955, p. 93, pl. 10, fig. 5.) is very similar to the penultimate instar from the Fordon borehole although the spination appears to be a little more prominent in the latter. The positioning of the two postero-ventral spines also differs slightly and the Russian form appears to lack the small spine in the sulcus, although this may not be apparent on the artist's drawing. In spite of these minor differences there is no doubt that the British and Wenden forms can be referred to this species with confidence. Sharapova's original figure is a right valve *not* a left and would seem to be an immature form probably belonging to instar 7 (Sharapova, 1939, pl. 3, fig. 34).

Subgenus **Acrocythere** Neale, **new subgenus**

Subgenotype: Orthonotacythere hauteriviana Bartenstein

Diagnosis: A subgenus of *Orthonotacythere* with hinge and internal features as in *Orthonotacythere, sensu stricto*, but differing in shape and ornament. The posterior end of the shell ends in a blunt point which lies on or about the level of the mid-line and not markedly dorsally as in *Orthonotacythere, sensu stricto*. Ornament is dominantly costate or reticulate, tubercles being absent or much reduced.

The subgenus is useful for accommodating species such as *Orthonotacythere hauteriviana* Bartenstein, *Lophocythere 1* and *1b* Bartenstein and Brand, 1951 and other Lower Cretaceous species as yet undescribed.

Orthonotacythere (Acrocythere) hauteriviana Bartenstein

Orthonotacythere hauteriviana BARTENSTEIN, 1956, Senckenbergiana Lethaea, vol. 37, p. 532, pl. 3, figs. 80, 81.

The diagnostic character of this easily recognized species is the interrupted mid-rib which is broken abruptly about one third of the way from the anterior end, the posterior end of the anterior part being deflected dorsally while the anterior end of the posterior part is deflected ventrally.

Bartenstein recorded this species from the lower Tealby Clay (upper Hauterivian) of Lincolnshire. The choice of name seems a little unfortunate since this species ranges through the Hauterivian and up into the Barremian. The *Cytheropteron* sp. described by Weber (1934, p. 144, pl. 9, figs. 4a–b) is a delicately sculptured variety of this which occurs at Wenden and also in the D1 and D2 beds of the Speeton Clay, at outcrop, but which has not been found in the Fordon borehole.

The new subspecies *anomala* is close to, if not identical with Bartenstein's form but since it is from the Barremian it has been thought advisable to give it a subspecific name indicating its anomalous stratigraphical position compared to the horizon suggested by its specific name.

Orthonotacythere (Acrocythere) hauteriviana Bartenstein subsp. **anomala** Neale, **new subspecies**
Plate 3, figure 7a–b; plate 4, figures 10, 14

Type: HU.1.C.2.25, a female left valve from 415 feet.

Dimensions of type: Length 0.53 mm.; height 0.31 mm.; proportion of height to length 59%.

Other material: Two left valves, three right valves, three fragments.

Horizon: North Fordon G.1, at 407, 415, 422 feet, Barremian.

Diagnosis: A subspecies of *Orthonotacythere hauteriviana* in which the ribs are high and knife-like and the whole pattern of reticulation and ribbing is accentuated to give a highly ornate carapace. The name *anomala* is given for the reasons above.

Orthonotacythere (Acrocythere) hauteriviana Bartenstein subsp. **laeva** Neale, **new subspecies**
Plate 3, figure 10a–b; plate 4, figure 13

Type: HU.1.C.2.26, a female left valve from 682 feet.

Dimensions of type: Length 0.48 mm.; height 0.29 mm.; proportion of height to length, 60%.

Other material: Four left valves, three right valves, two fragments.

Horizon: North Fordon G.1, at 653 feet 9 inches, 679, 682, 683 feet, upper Hauterivian.

Diagnosis: A subspecies of *Orthonotacythere hauteriviana* showing all the characteristic features of ornament but on a subdued scale. Instead of the ribs standing out as knife-like ridges they are scarcely differentiated from the surface of the shell and the strength of the reticulate pattern is similarly reduced. All the specimens from the four horizons noted above show this same type of reduced ornament. The characteristic features are shown in plate 3, figure 10a–b.

Orthonotacythere (Acrocythere) sp. α
Plate 3, figure 4a–b

Type: One female right valve: HU.1.C.2.45.

Dimensions of type: Length 0.42 mm.; height 0.25 mm.; proportion of height to length 60%.

Horizon: North Fordon G.1, 681 feet.

Remarks: The shape is typical of the new subgenus *Acrocythere* and ornament consists principally of a ventral rib which runs more or less parallel to the ventral and anterior margins of the shell and which is joined near the antero-ventral corner by one of the two ribs which occur *en echelon* on the mid-part of the shell. The posterior of these two ribs, which run from postero-dorsally to antero-ventrally, consists of two short lengths, while a third short rib or riblet lies horizontally above the gap between the two main ribs. Anteriorly the peripheral rib throws off two ribs which run to the anterior margin, whilst at the dorsal margin there is a plexus of fine ribs suggestive of the costation of this area in *O. hauteriviana*. As in this latter species there is a certain amount of anterior and posterior inflation which breaks up the straight outline of the dorsal margin. A very short, almost vertical rib is present postero-dorsally and the main body of the shell is marked off from the posterior extremity by a vertical rib or flange. Although closely related to *Orthonotacythere hauteriviana*, this would seem to be a new species. A great deal more material is needed, however, before its true relationship can be worked out and as only one specimen is known the nomenclature is left open.

Orthonotacythere (Acrocythere) sp. β
Plate 3, figure 3

Type: Three-quarters of a male (?) right valve, HU.1.C.2.19.

Dimensions: Length 0.40 mm.; height 0.22 mm.; proportion of height to length 55%.

Horizon: North Fordon G.1, 600 feet, upper Hauterivian.

Remarks: This differs from any figured species and shows the development of a thin, sharp longitudinal rib running well above the ventral margin, a very thin, fine rib running obliquely across the shell, and a posterior transverse rib which defines the posterior part of the main body of the valve. Pitting or reticulation is a marked feature of the surface and comes out well under the microscope. The specimen figured is the only material available and so *nomenclatura aperta* is employed.

Family Darwinulidae Brady and Norman
Genus Cyprione Jones, 1885

Cyprione cf. **C. oblonga** (Roemer)
Plate 1, figures 6, 8; plate 3, figures 9a–b, 11a–b; plate 4, figures 1–4

Cypris oblonga Roemer, 1839, Die Versteinerungen des norddeutschen Ooliten-Gebirges, Hannover, p. 52, pl. 20, fig. 21. – Dunker, 1846, Monographie der norddeutschen Wealdenbildung, Braunschweig, p. 60, pl. 13, figs. 26a, b.
Cyprione oblonga (Roemer). – Martin, 1940, Senckenbergiana, vol. 22, pp. 319–322, pl. 4, figs. 62, 63; pl. 11, fig. 164; pl. 12, fig. 173.

Horizon: North Fordon G.1, 880 feet 6 inches, Hauterivian.

Material: One carapace, three right valves and five left valves.

Dimensions: Left valve, instar 4, HU.1.C.2.53: length 0.33 mm.; height 0.18 mm.; width 0.070 mm.; right valve, instar 4, HU.1.C.2.54: length 0.32 mm.; height 0.16 mm.; width 0.067 mm.

The small size of these nine specimens from 880 feet, 6 inches made them difficult to interpret. They are here tentatively referred to one of the early moult stages of *Cyprione oblonga* (Roemer) and the position is discussed more fully below.

By comparison with the adult specimen figured by Martin (1940, pl. 12, fig. 173) the material described here belongs to instar 4. In spite of their small size (about 0.33 mm. in every case) the specimens are extremely well preserved but differ from the previously described members of this species, firstly, as regards the associated species and, secondly, in the muscle scar pattern. As a result it has been thought advisable to give a fuller description and more illustrations than would otherwise have been the case.

The genus *Cyprione* is poorly known and Grekoff (1956, p. 40) considers it to be synonymous with the freshwater genus *Darwinula*. The holotype of *Cyprione oblonga* comes from the Wealden of North Germany, whilst, in the present case all the associated ostracoda such as *Haplocytheridea kummi*, *Schuleridea wendenensis*, *Protocythere frankei*, *Orthonotacythere ramulosa* etc., are marine. No larger moults or adult specimens, even in a fragmentary condition occur in the Fordon material and this is perhaps significant. It suggests that these small specimens may have been swept into their present position

from a fresh or brackish water habitat by streams or bottom currents and have been killed off at an early stage by inimical conditions, in this case by the consequent increased salinity. In view of their fragility and the perfect preservation of the shell it is unlikely that they were derived from any pre-existing deposit and no such suitable source is, in fact, known to exist in the surrounding area.

The muscle scar pattern, which is of fundamental importance in the taxonomy of the *Podocopa*, has been shown by Martin to be of typical darwinulid type in the adult (*op. cit.* pl. 11, fig. 164). The muscle scars develop gradually throughout the period of growth, however, and only reach their final diversity and complexity in the adult form, so that there is no reason why the four vertical scars in these forms should not represent the primitive or ancestral pattern. If this hypothesis is rejected it becomes necessary to refer these specimens to some new genus probably belonging to the *Microcytherinae*. In view of their size this seems to be most undesirable and they are here compared to *Cyprione oblonga*.

Description: Carapace small, smooth and fragile. Shape typically cyprionid; elongate-oval, bluntly pointed anteriorly and rounded posteriorly; length twice or a little more than twice the height. Dorsal margin straight, ventral slightly concave, the whole shell tapering a little anteriorly. In dorsal view the shell is slim, almost parallel-sided, tapering slowly anteriorly and more rounded posteriorly. The dorsal margins of both valves are finely crenulate, the right valve overlapping the left valve dorsally. The straight dorsal edge of the left valve, which is finely crenulate, is accommodated in a crenulate groove under the dorsal margin in the right valve whose margin also appears to be finely crenulate.

The relative size of the valves in *Cyprione* is the subject of conflicting statements in the literature. Jones (1885, p. 344) stated that the right valve was larger than the left, and with this Pokorný agrees (1958, p. 301) although pointing out that in Recent species it is the left valve which is the larger. On the other hand, Martin (1940, p. 318) maintains that the left valve is the larger in the Cretaceous species and that Jones' illustration is at variance with the text. Martin appears to fall into this trap himself, however, for in his dorsal view of *Cyprione oblonga* (pl. 4, fig. 62) the right valve is clearly larger than the left. Here the relative overlap agrees with that defined by Jones and Pokorny.

The anterior part of inner lamella is poorly calcified and best seen when the shell is immersed in a medium such as benzyl alcohol; it appears to arise from behind the posterior part of the inner lamella near the mid-point of the ventral margin giving a characteristic cross-over effect. Its course is widely separated from the outline of the shell but roughly parallel to it.

Posteriorly, the inner lamella is strongly calcified and runs parallel to the posterior margin of the shell from which it is well separated, tapering in to join the ventral margin at about its mid-point. The line of concrescence is well separated from the inner margin both anteriorly and posteriorly. Radial pore canals are fine, hair-like, straight and numerous. Normal pore canals are small, sparse and evenly distributed.

Muscle scars consist of a vertical row of four slightly posterior to the mid-point of the valve and a group of three mandibular muscles lying more anteriorly. Certain small lucid spots which may be auxiliary muscles occur dorsally and are shown in the left valve figured in plate 1, figure 6. In muscle scar pattern the new genus bears most resemblance to *Microcythere* and there is a certain amount of resemblance in the marked separation of the inner margin and the line of concrescence but there is a marked difference in shape in which respect it agrees well with *Cyprione*.

Addendum: While this paper was in press the author had the opportunity of discussing the development of the muscle scar pattern in the Darwinulidae with Professor I. D. Pinto. Professor Pinto of the Universidade do Rio Grande do Sul, Brazil has carried out extensive work on the genus *Darwinula* and has shown that the characteristic rosette-shaped muscle pattern develops at an early stage. In view of this it would seem that the hypothesis tentatively advanced above is untenable and that the small forms here compared with *Cyprione oblonga* do in fact belong to a new genus. It is disappointing that no specimens of this interesting species have so far been obtained in work in progress on the Speeton Clay at outcrop. Until further material is available and it is certain that these small-sized specimens are adults it is not proposed to name this genus.

Family TRACHYLEBERIDIDAE Sylvester-Bradley
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley
Genus CYTHEREIS T. R. Jones, 1849

Cythereis acuticostata Triebel
Plate 3, figure 12; plate 4, figure 20

Cythereis acuticostata TRIEBEL, 1940, Senckenbergiana, vol. 22, pp. 186–188, pl. 4, figs. 43, 44. – 1941, ibid., vol. 23, pl. 15, fig. 163.

Horizons: North Fordon G.1, at 406, 407, 408, 409 feet, Barremian.

This species is known only in a fragmentary condition in the Fordon material, the most complete specimens being three-quarters of a left valve from 407 feet and two-thirds of a right valve from 406 feet. The left valve agrees well with Triebel's figures and description, the species being reticulate with three sharp, narrow, longitudinal ribs as described by that author. The middle rib runs uninterruptedly over the muscle node which is not particularly prominent, and is deflected downwards in its anterior course. The right valve (pl. 3, fig. 12) also agrees closely with Triebel's figures and shows the lower rib well separated from the median part of the ventral margin and the district "Leistchen" associated with it. The middle rib similarly shows the

obtuse angle where it crosses the muscle node. As in the type, the teeth in both valves are prominent and outstanding. The German specimens are Barremian and Aptian.

Cythereis senckenbergi Triebel
Plate 3, figure 14a–b; plate 4, figure 17

?*Cythereis ornatissima* var. *reticulata* Jones and Hinde. – Weber, 1934, Niedersächs. Geol. Ver., vol. 26, p. 142, pl. 8, fig. 3.

Non *Cythereis ornatissima* var. *reticulata* Jones and Hinde, 1890, Palaeontogr. Soc. London, Monogr., vol. 43, p. 24, pl. 1, figs. 67, 68, 71; pl. 4, figs. 9–12.

Cythereis senckenbergi Triebel, 1940, Senckenbergiana, vol. 22, pp. 180–186, pl. 2, fig. 31; pl. 3, figs. 32–42; pl. 9, fig. 105; pl. 10, fig. 106. – Slyvester-Bradley, 1948, Jour. Pal., p. 795, pl. 122, figs. 19, 23. – Deroo, 1956, Inst. Franç. Pétrole, Rev., vol. 11, p. 1516, pl. 4, figs. 54, 55.

Horizon: North Fordon G.1, 880 feet 6 inches, lower Hauterivian.

No adult specimens of this species were found but a number of moult stages occur at 880 feet 6 inches. These correspond exactly with the moult stages figured by Triebel (1940, pl. 3, figs. 39–42). The left valve of the penultimate instar is figured here (pl. 4, fig. 17). The German material is from the Hauterivian *noricus* – schichten, while in France, Deroo (1956) records it from the lower Hauterivian and lower Barremian.

CONCLUSIONS

Reference to Table 1 shows that three distinct marine ostracod faunas occur within the material examined. The breaks between these faunas are sharp and absolute, but this is probably more apparent than real since a gap of 197 feet in the cores separates the two lowest faunas, and a gap of 173 feet intervenes between the upper two.

The lowest fauna (880 feet 6 inches to 881 feet) is clearly comparable to that recorded from the lower Hauterivian *noricus* beds of the Continent and contains such species as *Haplocytheridea kummi*, *Schuleridea wendenensis*, *Protocythere frankei*, and *Cythereis senckenbergi*. These species all occur in the lower Hauterivian of Continental Europe and are particularly well known in the Hannover oilfield of northern Germany (Bettenstaedt and Wicher, 1943). The last two species are also known in similar deposits in the Yonne and Haute Marne districts of northern France. At outcrop this horizon is represented by some part of the lower C beds of the Speeton Clay, most probably by about C8–C9 since the ostracod fauna is not particularly close to that found in D1 and D2.

The middle fauna (652–683 feet) is characterised by abundant *Dolocytheridea hilseana* and *Protocythere triplicata* together with *Orthonotacythere inversa*, *Schuleridea bilobata* and *Apatocythere simulans*. Previously these species have been found in both upper Hauterivian and lower Barremian rocks but as there is a lack of any of the normal lower Barremian associates the fauna is here regarded as upper Hauterivian (Deroo, 1956). Cores 9 and 11 yielded insufficient evidence to assess their stratigraphic position but they are here provisionally referred to the upper Hauterivian.

The upper fauna (406–426 feet) proved to be the poorest from the quantitative point of view, but contained typical Barremian forms such as *Cytherella pyriformis* and *Cythereis acuticostata*. The former occurs in the lower Barremian in northern France and the latter in the upper Barremian in northern Germany. *Gavelinella barremiana*

PLATE 1

All specimens are from the North Fordon G. 1. borehole, with depths given in feet below rotary table elevation. All figures × 90, except where stated.

1–2 *Macrocypris?* sp. β
1, side view, left valve, HU. 1. C. 2. 39; 653 feet, upper Hauterivian; 2, side view, carapace, HU. 1. C. 2. 36; 682 feet, upper Hauterivian.

3 *Macrocypris?* sp. γ
Side view, left valve, HU. 1. C. 2. 20; 408 feet, Barremian.

4 *Paracypris* sp. α
Side view, carapace, HU. 1. C. 2. 37; 683 feet, upper Hauterivian.

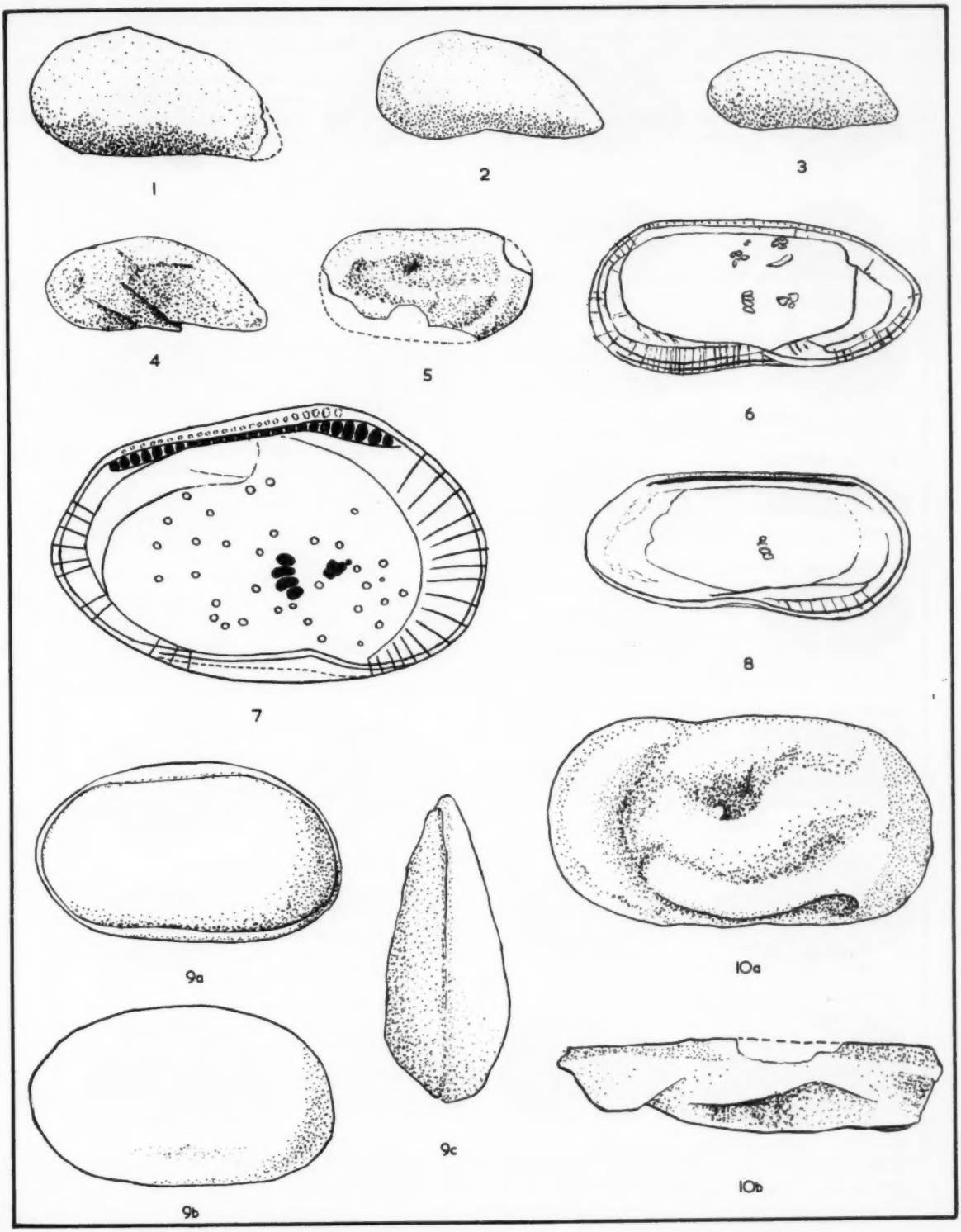
5 *Cytherelloidea* sp. α
Side view, right valve, HU. 1. C. 2. 40; 408 feet, Barremian.

6, 8 *Cyprione* cf. *oblonga* (Roemer)
6, left valve from inside, × 186, instar 4, HU. 1. C. 2. 53; 8, right valve from inside, × 186, instar 4, HU. 1. C. 2. 54; 880 feet 6 inches, lower Hauterivian.

7 *Haplocytheridea kummi* Triebel
Left valve from inside, HU. 1. C. 2. 70; 881 feet, lower Hauterivian.

9 *Cytherella pyriformis* (Cornuel)
Carapace, HU. 1. C. 2. 44; 408 feet, Barremian; 9a, from left, 9b, from right, 9c, dorsal view.

10 *Cytherelloidea pulchra* Neale, n. sp.
Holotype, female left valve, HU. 1. C. 2. 65; 10a, from left; 10b, dorsal view, 681 feet, upper Hauterivian.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first appears somewhat sporadically in these cores, being a much more constant member of the fauna in the higher cores (270–305 feet), which suggests that this fauna belongs to the upper part of the lower Barremian or the very beginning of the middle Barremian.

The most disappointing feature of this borehole lies in the poor development of ostracodes in the upper half of the Speeton Clay. In the lower half the faunas are generally good and enable one to assign a minimum of 228 feet of clay to the Hauterivian. This is nearly twice the maximum thickness of the Hauterivian at outcrop (122 feet 6 inches) and suggests that the Hunmanby fault may have already been in existence in Lower Cretaceous times and had a controlling effect on the development of sedimentation to the west.

PLATE 2

All specimens from the North Fordon G. 1. borehole, with depths given in feet below rotary table elevation. All magnifications are × 38.

1 *Schuleridea rhomboidalis* Neale, n. sp.
Holotype, female carapace HU. 1. C. 2. 99; 657 feet, upper Hauterivian; 1a, right side; 1b, dorsal view.

2 *Schuleridea rhomboidalis* Neale, n. sp.
Female left valve, HU. 1. C. 2. 94; 653 feet 9 inches, upper Hauterivian.

3 *Apatocythere simulans* Triebel
Female carapace, HU. 1. C. 2. 95; 653 feet 9 inches, upper Hauterivian; 3a, left side; 3b, dorsal view.

4 *Schuleridea* aff. *thorenensis* Triebel
Female carapace, left side, HU. 1. C. 2. 86; 880 feet 6 inches, lower Hauterivian.

5 *Schuleridea rhomboidalis* Neale, n. sp.
Paratype, female carapace, right side, HU. 1. C. 2. 98; 657 feet, upper Hauterivian.

6 *Schuleridea* aff. *thorenensis* Triebel
Female carapace from left, HU. 1. C. 2. 85; 880 feet 6 inches, lower Hauterivian.

7 *Schuleridea rhomboidalis* Neale, n. sp.
Paratype, male right valve, HU. 1. C. 2. 97; 657 feet, upper Hauterivian.

8 *Schuleridea rhomboidalis* Neale, n. sp.
Paratype, male right valve, HU. 1. C. 2. 100; 657 feet, upper Hauterivian.

9 *Apatocythere simulans* Triebel
Female right valve, HU. 1. C. 2. 96; 653 feet 9 inches, upper Hauterivian.

10 *Schuleridea wendenensis* Neale, new name.
Female right valve, HU. 1. C. 2. 89; 881 feet, lower Hauterivian.

11 *Haplocytheridea kummi* Triebel
Male carapace, HU. 1. C. 2. 74; 881 feet, lower Hauterivian; 11a, left side; 11b, dorsal view.

12 *Schuleridea wendenensis* Neale, new name.
Male carapace, HU. 1. C. 2. 90; 881 feet, lower Hauterivian; 12a, left side; 12b, dorsal view.

13 *Dolocytheridea hilseana* (Roemer)
Female left valve, HU. 1. C. 2. 69; 654 feet, upper Hauterivian; 13a, ventral view; 13b, side view, transmitted light.

14 *Protocythere triplicata* (Roemer)
Right valve, instar 7?, HU. 1. C. 2. 78; 654 feet, upper Hauterivian.

15 *Haplocytheridea kummi* Triebel
Female right valve, HU. 1. C. 2. 72; 881 feet, lower Hauterivian.

16 *Schuleridea bilobata* Triebel
Female carapace, HU. 1. C. 2. 92; 654 feet, upper Hauterivian; 16a, right side; 16b, dorsal view.

17 *Haplocytheridea kummi* Triebel
Female carapace, HU. 1. C. 2. 71; 881 feet, lower Hauterivian; 17a, left side; 17b, dorsal view.

18 *Protocythere frankei* Triebel
Carapace, HU. 1. C. 2. 57; 881 feet, lower Hauterivian; 18a, dorsal view; 18b, right side.

19 *Dolocytheridea hilseana* (Roemer)
Male right valve, HU. 1. C. 2. 66; 654 feet, upper Hauterivian.

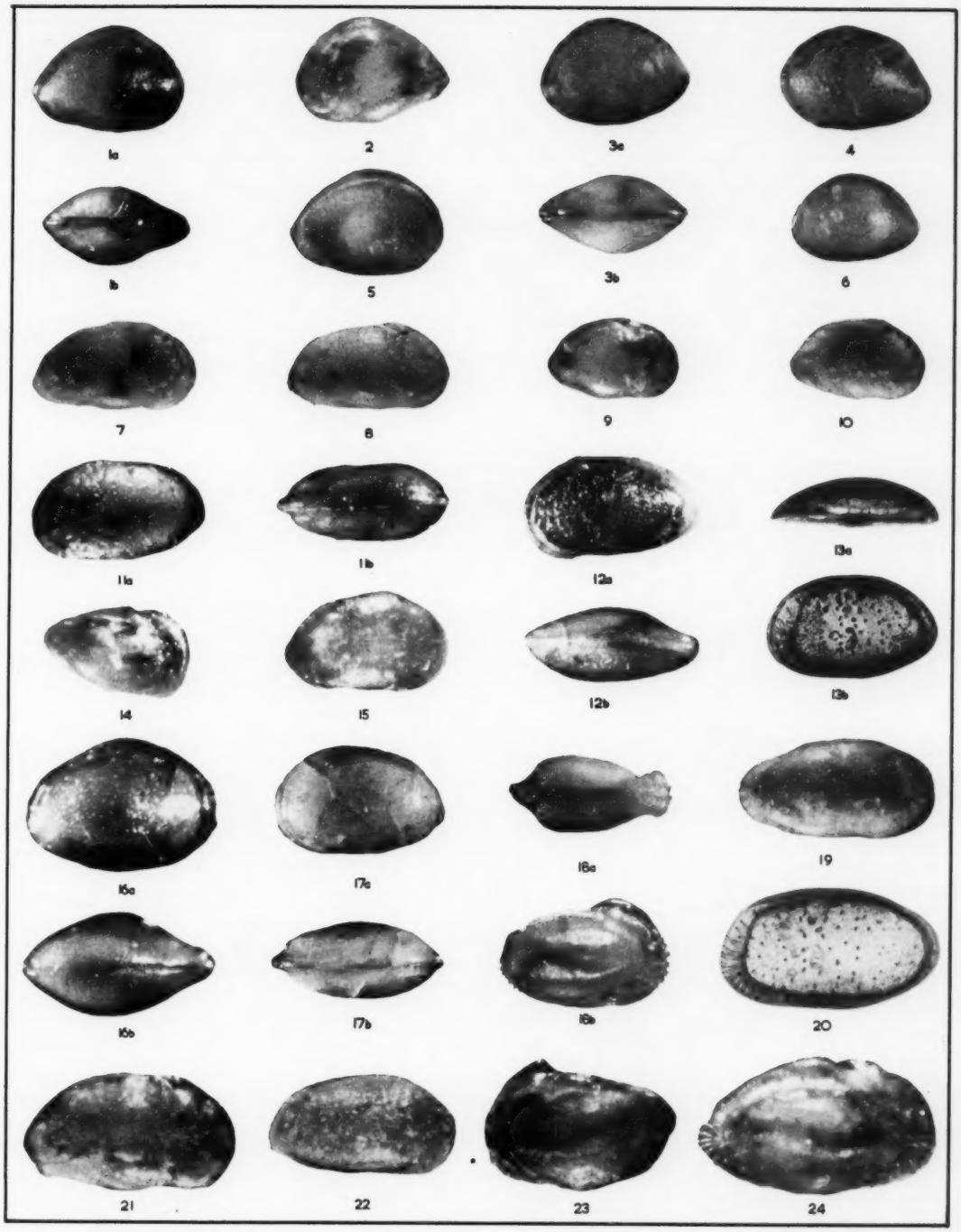
20 *Dolocytheridea hilseana* (Roemer)
Male left valve, HU. 1. C. 2. 68; 654 feet, upper Hauterivian, transmitted light.

21 *Schuleridea bilobata* Triebel
Male right valve, HU. 1. C. 2. 93; 653 feet 9 inches, upper Hauterivian.

22 *Haplocytheridea kummi* Triebel
Male right valve, HU. 1. C. 2. 73; 881 feet, lower Hauterivian.

23 *Protocythere triplicata* (Roemer)
Left valve, adult, HU. 1. C. 2. 76; 654 feet, upper Hauterivian.

24 *Protocythere triplicata* (Roemer)
Right valve, adult, HU. 1. C. 2. 75; 654 feet, upper Hauterivian.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(continued on page 224)

PLATE 3

All specimens are from North Fordon G. 1. borehole, except figure 8. Depths are given in feet below rotary table elevation.

1 *Orthonotacythere* (*Orthonotacythere*) *inversa* (Cornuel)
Female left valve × 83, instar 8, HU. 1. C. 2. 28, 681 feet, upper Hauterivian; 1a, side view; 1b, dorsal view.

2 *Orthonotacythere* (*Orthonotacythere*) *anglica* Neale, n. sp.
Female left valve × 77, instar 8, HU. 1. C. 2. 33, 880 feet 6 inches, lower Hauterivian; 2a, side view; 2b, dorsal view.

3 *Orthonotacythere* (*Acrocythere*) sp. β
Male? right valve, side view × 85, HU. 1. C. 2. 19, 600 feet, upper Hauterivian.

4 *Orthonotacythere* (*Acrocythere*) sp. α
Female? right valve × 84, HU. 1. C. 2. 45, 681 feet, upper Hauterivian; 4a, side view; 4b, dorsal view.

5 *Orthonotacythere* (*Orthonotacythere*) *inversa* (Cornuel)
Male left valve × 86, instar 8, HU. 1. C. 2. 38; 657 feet, upper Hauterivian; 5a, side view; 5b dorsal view.

6 *Orthonotacythere* (*Orthonotacythere*) *anglica* Neale, n. sp.
Male left valve, specimen lost, side view; 880 feet, 6 inches, lower Hauterivian.

7 *Orthonotacythere* (*Acrocythere*) *hauteriviana anomala* Neale, n. subsp.
Female left valve × 73, HU. 1. C. 2. 25; 415 feet, Barremian; 7a, side view; 7b, dorsal view.

8 *Orthonotacythere* (*Orthonotacythere*) *ramulosa* Sharapova
Adult female carapace × 86, HU. 1. C. 3; Speeton Clay C 3, Hauterivian; 8a, left side; 8b, dorsal view.

9 *Cyprione* cf. *C. oblonga* (Roemer)
Left valve × 121, instar 4, HU. 1. C. 2. 53; 880 feet 6 inches, lower Hauterivian; 9a, side view; 9b, dorsal view.

10 *Orthonotacythere* (*Acrocythere*) *hauteriviana laeva* Neale, n. subsp.
Female left valve × 74, HU. 1. C. 26; 682 feet, upper Hauterivian; 10a, side view; 10b, dorsal view.

11 *Cyprione* cf. *C. oblonga* (Roemer)
Right valve × 131, instar 4, HU. 1. C. 2. 54; 880 feet 6 inches, lower Hauterivian; 11a, side view; 11b, dorsal view.

12 *Cythereis acuticostata* Triebel
Right valve × 71, HU. 1. C. 2. 23; 406 feet, Barremian.

13 *Orthonotacythere* (*Orthonotacythere*) *ramulosa* Sharapova
Female left valve × 81, instar 8, HU. 1. C. 2. 27; 880 feet 6 inches, lower Hauterivian; 13a, side view; 13b, dorsal view.

14 *Cythereis senckenbergi* Triebel
Left valve × 82, instar 8, HU. 1. C. 2. 47; 880 feet 6 inches, lower Hauterivian; 14a, side view; 14b, dorsal view.

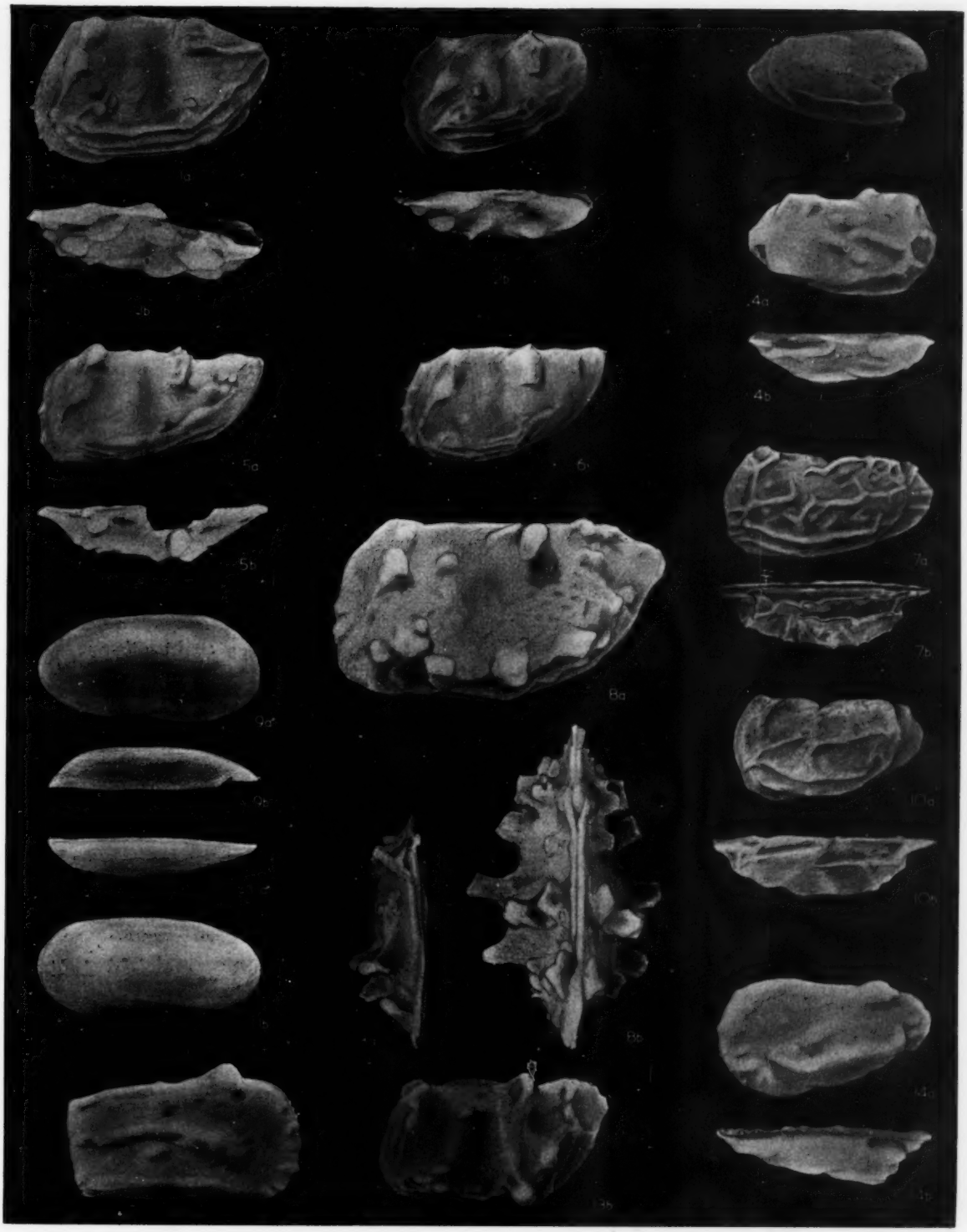


PLATE 4

All specimens are from the North Fordon G. 1. borehole, with depths given in feet below rotary table elevation.

1 *Cyprione* cf. *C. oblonga* (Roemer)
Left valve × 117, instar 4, HU. 1. C. 2. 53, side view, in transmitted light; 880 feet 6 inches, lower Hauterivian.

2 *Cyprione* cf. *C. oblonga* (Roemer)
Right valve × 111, instar 4, HU. 1. C. 2, 54, side view in transmitted light; 880 feet 6 inches, lower Hauterivian.

3 *Cyprione* cf. *C. oblonga* (Roemer)
Right valve × 115, instar 4, HU. 1. C. 2. 52, side view in transmitted light; 880 feet 6 inches, lower Hauterivian.

4 *Cyprione* cf. *C. oblonga* (Roemer)
Right valve × 114, instar 4, HU. 1. C. 2. 51, side view in transmitted light; 880 feet 6 inches, lower Hauterivian.

5 *Macrocypris*? sp. α
Carapace, left side × 81, HU. 1. C. 2. 55; 880 feet 6 inches, lower Hauterivian.

6 *Paracypris* sp. α
Left valve × 79, HU. 1. C. 2. 56; 657 feet, upper Hauterivian; 6a, side view; 6b, dorsal view.

7 *Orthonotacythere* (*Orthonotacythere*) *anglica* Neale, n. sp.
Male right valve × 76, instar 7, HU. 1. C. 2. 50; 880 feet 6 inches, lower Hauterivian transmitted light.

8 *Orthonotacythere* (*Orthonotacythere*) *anglica* Neale, n. sp.
Male left valve × 95, instar 7, HU. 1. C. 2. 31, seen in transmitted light; 880 feet 6 inches, lower Hauterivian.

9 *Orthonotacythere* (*Orthonotacythere*) *anglica* Neale, n. sp.
Female right valve × 79, instar 8, HU. 1. C. 2. 33, seen in transmitted light; 880 feet 6 inches, lower Hauterivian.

10 *Orthonotacythere* (*Acrocythere*) *hauteriviana anomala* Neale, n. subsp.
Right valve × 76, juvenile, HU. 1. C. 2. 43, seen in transmitted light; 415 feet, Barremian.

11 *Orthonotacythere* (*Orthonotacythere*) *inversa* (Cornuel)
Left valve × 89, instar 8, HU. 1. C. 2. 30, in transmitted light; 657 feet, upper Hauterivian.

12 *Orthonotacythere* (*Orthonotacythere*) *anglica*, Neale, n. sp.
Male left valve × 77, instar 8, HU. 1. C. 2. 32, in transmitted light; 880 feet 6 inches, lower Hauterivian.

13 *Orthonotacythere* (*Acrocythere*) *hauteriviana laeva* Neale, n. subsp.
Male? left valve × 85, HU. 1. C. 2. 26, in transmitted light; 682 feet, upper Hauterivian.

14 *Orthonotacythere* (*Acrocythere*) *hauteriviana anomala* Neale, n. subsp.
Female left valve × 75, adult, HU. 1. C. 2. 25, in transmitted light; 415 feet, Barremian.

15 *Orthonotacythere* (*Orthonotacythere*) *ramulosa* (Sharapova)
Left valve × 76, instar 8, HU. 1. C. 2. 27, in transmitted light; 880 feet 6 inches, lower Hauterivian.

16 *Orthonotacythere* (*Orthonotacythere*) *anglica* Neale, n. sp.
Male right valve × 78, adult, broken, HU. 1. C. 2. 49, in transmitted light; 880 feet 6 inches, lower Hauterivian.

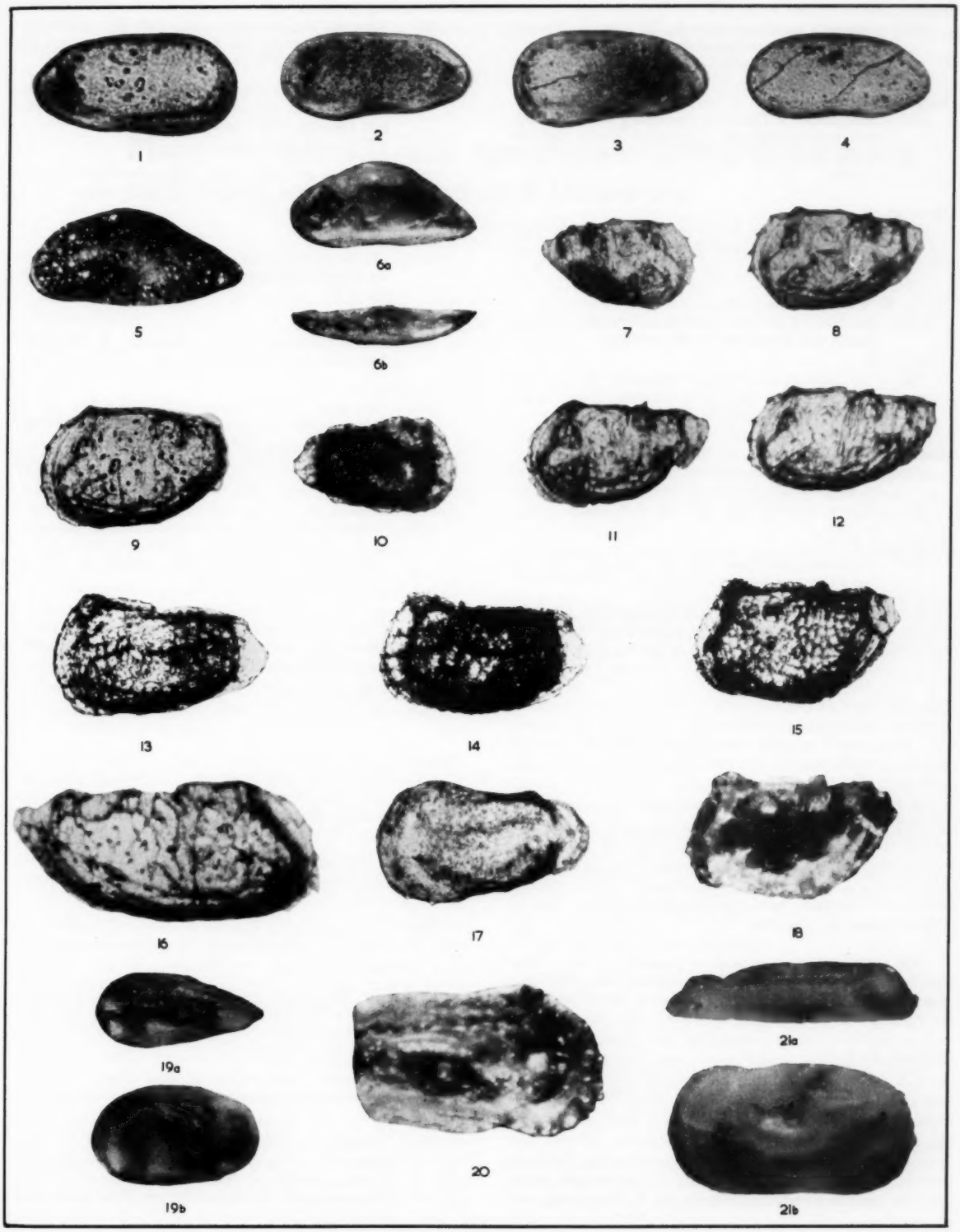
17 *Cythereis senckenbergi* Triebel
Juvenile left valve × 83, HU. 1. C. 2. 47, in transmitted light; 880 feet 6 inches, lower Hauterivian.

18 *Orthonotacythere* (*Orthonotacythere*) *ramulosa* (Sharapova)
Left valve × 76, instar 8, HU. 1. C. 2. 27, in reflected light; 880 feet 6 inches, lower Hauterivian.

19 *Cytherella pyriformis* (Cornuel)
Carapace × 60, HU. 1. C. 2. 44, in reflected light; 408 feet, Barremian; 19a, dorsal view; 19b, right side.

20 *Cythereis acuticostata* Triebel
Anterior part of right valve × 77, HU. 1. C. 2. 23, in reflected light; 406 feet, Barremian.

21 *Cytherelloidea pulchra* Neale, n. sp.
Female left valve × 65, HU. 1. C. 2. 65; 681 feet, upper Hauterivian; 21a, ventral view; 21b, side view.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ABSTRACT: *A study of spores and pollen in nonmarine sediments of Cretaceous age from Maryland and Delaware indicates that these deposits range from Lower Cretaceous to lowermost Upper Cretaceous. Twenty-two species of spores and pollen are described, eleven of which are new.*

Plant microfossils and age of nonmarine Cretaceous sediments of Maryland and Delaware

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INTRODUCTION

There is no unanimity of opinion concerning the age of the nonmarine Cretaceous deposits of Maryland and Delaware. Sediments which have been mapped as Arundel and Patapsco formations are considered Lower Cretaceous by some writers and Upper Cretaceous by others. It is the purpose of this paper to present palynological data which have a bearing on this question. No inferences concerning the paleoecological significance of the floras have been made.

Only those pollen and spores are described which are common in one or more samples or which appear to have stratigraphic significance. Further detailed work is needed to fully describe the pollen and spore flora of the Cretaceous sediments of the Coastal Plain.

All slides and sources of original types are deposited in the Delaware Geological Survey Office, University of Delaware, Newark, Delaware.

PREVIOUS INVESTIGATIONS

The age of the sediments of the Potomac group (Patuxent, Arundel and Patapsco formations) was considered Jurassic by Marsh (1896) on the basis of dinosaurian remains. Fontaine (1889) and Berry (Clark, Bibbins and Berry, 1911) assigned an early Cretaceous age to the Potomac group on the basis of thorough paleobotanical investigations which included a study of the Cretaceous floras of the world.

Gilmore (1921) expressed the opinion that the Arundel formation is of late early Cretaceous age, although the vertebrate evidence is apparently scant and somewhat difficult to interpret. He stated (p. 592): "Summing up the evidence, such as it is, we have on the one hand in the Arundel the presence of sauropodous dinosaurs which have been generally considered as not having survived after the close of the Morrison, and on the other hand one family of known Upper Cretaceous occurrence, and at least three other forms which have their closest resemblances with Upper Cretaceous dinosaurs. Imperfect as it is, the weight of the vertebrate evidence would appear to favor a higher position in the geological scale than has been attributed this fauna in the past."

This statement indicates that Gilmore was aware of the uncertainty of his age assignment, and might suggest that greater attention should be given to the abundant fossil plant record.

Vokes (Anderson et al., 1948) considered the Patuxent formation Lower Cretaceous and the undifferentiated Arundel-Patapsco formation Upper Cretaceous. His age assignment is based on a predominantly molluscan fauna from a core obtained at a depth of 4875–4885 feet from the Maryland Esso Hammond well no. 1. Several genera, and all species were described as new. In spite of the obvious difficulties involved in determining the age of this fossil assemblage, Vokes considered it Upper Cretaceous. He stated (p. 132): "... the fauna, if not strictly contemporaneous with the Woodbine sand, is probably still to be assigned to some horizon within the lower Cenomanian."

Spangler and Peterson (1950) agreed with Gilmore and Vokes that the Arundel formation is Upper Cretaceous. They considered only the Patuxent to be Lower Cretaceous. Their main arguments in favor of this assignment, however, were not based on paleontological evidence. They considered it improbable that a great thickness of Lower Cretaceous sediments in Delaware, Maryland, and Virginia would abut against Upper Cretaceous sediments of the same lithologic character in the Raritan formation in New Jersey and the Tuscaloosa formation in North Carolina. Spangler and Peterson attempted to demonstrate this with the aid of three

drawings (p. 68, fig. 5, 6 and 7), but it appears that they might have been misled by the fact that the vertical scale in these figures was greatly exaggerated.

Dorf (1952) re-examined the paleontological record of the Atlantic Coastal Plain. He showed, as Berry had done before him, that the floras of the Patuxent and Arundel formations are essentially the same, and that all of the floras of the Potomac group have distinct Lower Cretaceous affinities.

The interpretations as to the age of the nonmarine Cretaceous sediments by Berry, Spangler and Peterson and Dorf are presented in Table 1.

SAMPLING LOCALITIES

Samples were obtained in the following localities, shown in text-figure 1.

1) Abandoned pit near Edgewood, Maryland, along U. S. Route 40, 0.35 miles west of intersection of U. S. Route 40 and Route 24. Sediments of the Patuxent formation occur in this locality according to the geologic map of Maryland.

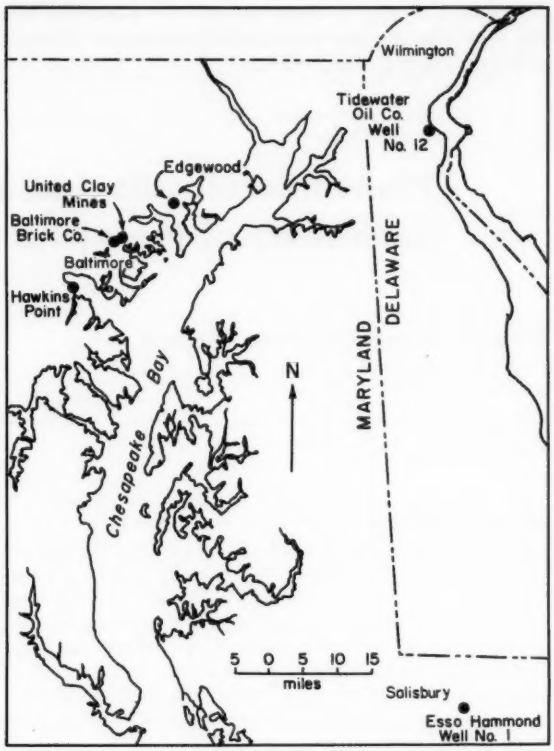
2) United Clay Mines, Inc., along U. S. Route 40, south side, 0.3 miles west of Middle River road. Arundel and Patapsco formations occur in this area according to the geologic map.

3) Baltimore Brick Co., along U. S. Route 40, about 0.3 miles west of locality 2, mapped as Arundel formation.

4) Hawkins Point, Maryland, near Baltimore, mapped as Patapsco formation.

5) Esso Hammond well no. 1 near Salisbury, Maryland, samples from 1668–1678 ft., 2363–2373 ft., 4980–4985 ft., 5104–5112 ft., and 5130–5135 ft.

6) Tidewater Oil Company well no. 12 near Delaware City, Delaware; samples from 740, 715, 515 and 275 ft. below land surface.



TEXT-FIGURE 1
SAMPLE LOCALITIES

CHARACTERISTIC PLANT MICROFOSSILS

The most abundant plant microfossils are fern spores, inaperturate pollen of uncertain affinity, pollen of conifers belonging to the Pinaceae and the Taxodiaceae or Cupressaceae. In some samples, significant percentages of undoubted angiosperm pollen occur. Finally, some pollen were found which should probably be referred to the Cycadales or Ginkgoales.

The percentages in which these groups of fossils occur are presented in Table 2. The distribution of the species described in this report is shown in Table 3.

Among the fern spores, the most common are *Cicatricosisporites goepperti*, *C. dorogensis*, *Dictyophyllidites harrisii*, and *Trilobosporites apiverrucatus*. Occurring occasionally are *Cingulatisporites psilatus*, *Densoisporites perinatus*, *Pilosisporites trichopapillosus* and *Appendicisporites tricornitatus*. The commonly occurring spores mentioned above, with the exception of *Dictyophyllidites harrisii*, belong to the fern family, Schizaeaceae, according to Couper (1958). The Pinaceae are represented by several species of *Abietineaepollenites*. One species occurring frequently is very similar to modern *Pinus*, with a well-developed "frill" around the body and large bladders, as in *Abietineaepollenites grandialatus*. Another species, *A. microreticulatus*, is morphologically similar to the modern *Picea*. A small *Pinus*-type pollen, *A. parvus*, was also noted.

Inaperturate pollen with "split" exine, psilate or indistinctly scabrate, are common, represented by *Inaperturopollenites hiatus*. They are probably referable to the Taxodiaceae or Cupressaceae.

Monocolpate grains, such as *Monosulcites minimus*, having the morphological characteristics of Cycad or Ginkgo pollen, occur in small number in nearly all samples.

Inaperturate pollen of uncertain affinity, such as *Inaperturopollenites dubius*, are most abundant. In Table 2 they form by far the greatest percentage of the Incertae sedis. Thomson and Pflug (1953) suggested a coniferous origin for them.

TABLE 1

Age assignments of nonmarine Cretaceous deposits of Maryland and Delaware by Berry (1911, 1916), Spangler and Petersen (1950) and Dorf (1952).

			European equivalents	Berry, 1911, 1916	Spangler & Peterson, 1950	Dorf, 1952
CRETACEOUS	UPPER	SENONIAN	Campanian			
			Santonian		Magothy	
			Coniacian			Magothy fm.
		Turonian		Magothy	Absent in outcrop	
					"Raritan"	Raritan fm.
		Cenomanian		Raritan	Patapsco Arundel	
					— — ? — — ? — —	
	LOWER	Albian		Patapsco	Patuxent	Patapsco
		Aptian			— — ? — — ? — —	Arundel fm.
		Neocomian		Arundel Patuxent		Patuxent fm.

Undoubted angiosperm pollen occur mainly in the samples from Edgewood, Hawkins Point, the Hammond well at 1668–78 feet depth and the Tidewater well at 275 feet. Tricolpate and tricolporate pollen predominate; triporate pollen of triangular shape which are abundant in the Senonian of Europe (Weyland and Krieger, 1953) and which occur also in the Magothy formation of Delaware according to preliminary investigation by the present writers, have not been found in the nonmarine Cretaceous sediments.

AGE

The floras represented by the pollen assemblages shown in Tables 2 and 3 represent not only stages in the evolution of the plant kingdom, but also local paleoecological factors. The influence of the latter is clearly indicated by the pollen and spore percentages of samples U.C.M. no. 1 and U.C.M. no. 2. Although at the time of deposition of the sediments found in the United Clay Mines pit, conifers were present in abundance, local conditions favored the growth of ferns at some places (U.C.M. no. 2). Thus, considerable variation in vegetation occurred from place to place, as it does indeed at present. In spite of this variation, the pollen and spore assemblages permit the approximate age assignment of the sediments.

The samples from United Clay Mines, the Hammond well, with the exception of the sample from 1668–78 ft. and the Tidewater well with the exception of the sample from 275 ft. contain no or very few angiosperm pollen. This feature, and the occurrence of fern spores such as *Cicatricosisporites goepperti*, *C. dorogensis*, and *Trilobosporites apiverrucatus*, which are common in the Wealden of England (Couper, 1958), although not necessarily restricted to it, strongly suggest an Early Cretaceous age. The samples from Hawkins Point, the Hammond well at a depth of 1668–78 feet, and the Tidewater well at a depth of 275 feet, contain high percentages of angiosperm pollen and should be assigned to the Upper Cretaceous. The absence of triporate "Dreieckpollen" which are abundant in the Senonian of Europe (Weyland and Krieger, 1953) indicates an early Late Cretaceous (pre-Senonian) age. Thus, the sediments which have been assigned to the Patuxent and Arundel-Patapsco formations by Anderson (1948) in the Hammond well are apparently of Early Cretaceous age on palynological evidence, and the sediments assigned to the Raritan formation are of Late Cretaceous age.

TABLE 2

Plant microfossils, nonmarine Cretaceous sediments, Maryland and Delaware.
Major groups of pollen and spores, in percentages.

	UCM # 1	UCM # 2	Edgewood # 2	Baltimore Brick # 1	Baltimore Brick # 2	Hawkins P. # 1	Hawkins P. # 2	Hawkins P. # 4	Esso Hammond well no. 1					Tidewater Oil Company well no. 12			
									5130–35 ft.	5104–12 ft.	4980–85 ft.	2363–73 ft.	1668–78 ft.	740 ft.	715 ft.	515 ft.	275 ft.
Ferns and fern allies	17	70	7	28	49	12	7	8	12	12	13	16	19	12	23	45	5
Pinaceae	9	11	22	16	24	13	14	18	24	27	21	31	7	14	29	15	2
Cupressaceae and Taxodiaceae	34	—	14	15	—	10	10	6	8	1	3	18	4	7	11	6	11
Cycadales and Ginkgoales	11	—	1	5	2	13	3	2	7	5	6	5	16	1	1	6	12
Undoubted angiosperms	1	—	21	8	12	23	34	21	—	—	2	5	28	2	1	1	25
Incertae sedis*	28	19	35	28	13	29	32	45	49	55	55	25	26	64	35	27	45

*Mostly *Inaperturopollenites dubius*

The deposits of the Potomac group consisting of the Patuxent, Arundel and Patapsco formations and the Raritan formation are lithologically so similar that it is impossible to differentiate between them in outcrops (Groot, 1955, p. 25). This difficulty is demonstrated by comparing formation assignments and the age of the sediments as indicated by their pollen assemblages, particularly their angiosperm content (Table 4).

TABLE 4

Angiosperm pollen content of nonmarine Cretaceous formations as shown on the geologic map of Maryland or as described in the literature (Anderson *et al.*, 1948).

Formation	Locality	Angiosperm pollen %
Raritan	Hammond well, 1668–78 ft.	28
Patapsco	Hawkins Point	26*
Arundel-Patapsco	Hammond well, 2363–73 ft.	5
Arundel-Patapsco	Hammond well, 4980–85 ft.	2
Arundel	Baltimore Brick Co.	10*
Patuxent	Edgewood	21
Patuxent	Hammond well, 5104–12 ft.	0
Patuxent	Hammond well, 5130–35 ft.	0

*average percentages

Note: The sediments of the Tidewater well have not been assigned formational names.

Thus, if the mapping of the nonmarine Cretaceous deposits be correct, then the formations vary in age with locality as suggested by the palynological record. Actually, the lithologic similarity of the "formations" has made accurate mapping impossible.

SUMMARY AND CONCLUSIONS

The pollen and spore assemblages indicate that the mapping of the nonmarine Cretaceous formations in the area investigated is in error. The lithologic similarity of the deposits is the cause of this error, as pointed out previously by Groot (1955).

The nonmarine Cretaceous sediments are both Lower and lowermost Upper Cretaceous. The stratigraphically lowermost sediments are probably of Neocomian age because of the similarity of their pollen and spore content to the Wealden of England. The uppermost sediments, containing relatively few fern spores, and 20 per cent or more dicotyledonous angiosperm pollen are pre-Senonian in age, probably Cenomanian. Sediments of Aptian and Albian age may be present, but this cannot be demonstrated on the basis of the limited number of samples investigated.

The age assignment based on the palynological data is in general agreement with that based on plant megafossils (Berry, 1911, 1916; Dorf, 1952) and is in disagreement with that of Spangler and Peterson (1950).

TABLE 3

Distribution of plant microfossils in nonmarine Cretaceous sediments of Maryland and Delaware.

Plant microfossil species	UGM # 1	UGM # 2	Edgewood # 2	Baltimore Brick # 1	Baltimore Brick # 2	Hawkins P. # 1	Hawkins P. # 2	Hawkins P. # 4	Esso Hammond well no. 1					Tidewater Oil Company well no. 12			
									5130–35 ft.	5104–12 ft.	4980–85 ft.	2363–73 ft.	1668–78 ft.	740 ft.	715 ft.	515 ft.	275 ft.
Lycopodiumsporites clavatoides									×	×						×	
Appendicisporites tricornitatus						×		×									
Cicatricosisporites dorogensis						×								×		×	
Cicatricosisporites goepperti	×			×				×			×					×	
Dictyophyllidites harrisii	×			×	×	×		×	×	×	×						×?
Trilobosporites apiverrucatus	×	×			×				×							×	
Pilosisporites trichopapillosus								×	×								
Densoisporites perinatus									×								
Cingulatisporites psilatus	×	×		×													
Monosulcites minimus	×			×		×			×	×	×					×	×
Inaperturopollenites hiatus	×		×	×			×	×	×	×	×	×	×	×	×	×	×
Abietineaepollenites, all species	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Inaperturopollenites dubius	×	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×
Eucommiidites minor								×	×								
Tricolpopollenites crassimurus				×	×		×	×									
Tricolpopollenites micromunus						×	×	×									×
Tricolpopollenites parvulus													×				×
Tricolporopollenites subobscurus			×														
Tricolporopollenites distinctus																	×
Tricolporopollenites planus								×									

SYSTEMATIC DESCRIPTIONS

LYCOPODIALES
Family LYCOPODIACEAE
Genus LYCOPODIUMSPORITES Thiergart, 1938

Lycopodiumsporites clavatoides Couper
Plate 1, figure 1

Description: Trilete; equatorial contour rounded-triangular; coarsely reticulate with ridges about 1μ wide and up to 3μ high; the projections are embedded in a transparent hyaline layer; size about 35μ.

Illustrated specimen: Hammond well, 5104–12 ft., slide A, 93.4 × 13.9.

Remarks: This specimen appears to be identical with the one described by Couper (1958) from the Jurassic and Lower Cretaceous of England.

FILICALES
Family SCHIZAEACEAE
Genus APPENDICISPORITES Weyland and Krieger, 1953

Appendicisporites tricornitatus Weyland and Greifeld
Plate 1, figure 4

Description: Trilete; laesurae long and straight; equatorial contour triangular, slightly convex; striate, with ridges about 2μ wide and 3μ apart; apical projections 8μ high; size about 48μ.

Illustrated specimen: Hawkins Point, slide 4a, 102.0 × 2.3.

Genus CICATRICOSISPORITES R. Potonié and Gelletich, 1933

Cicatricosisporites dorogensis R. Potonié and Gelletich
Plate 1, figure 2

Mohriosporites dorogensis R. Potonié, 1951, Palaeontographica, pt. B, vol. 91, pl. 20, fig. 14.

Description: Trilete; laesurae reaching equator; equatorial contour triangular, slightly convex; distal face striate with numerous ridges about 2μ high and 1.5 to 2μ apart, forming a "criss-cross" pattern; exine thickness 1.5 to 2μ; size about 40μ.

Illustrated specimen: Hawkins Point, slide 1b, 78.7 × 5.2.

Remarks: This grain is identical to the ones described by Couper from the upper Jurassic and Lower Cretaceous of England and by Potonié from the Eocene and Oligocene of Germany.

Cicatricosisporites goepperti Groot and Penny, **new combination**
Plate 2, figures 20, 22

Ruffordia goepperti Seward, 1913, Quart. Jour. Geol. Soc., vol. 69, text-fig. 2A.

Description: Trilete; laesurae about three-quarters of radius of grain; equatorial contour triangular, slightly concave; striate, with ridges about 1.2μ high and 2.5μ wide, spaced at 1 to 2μ intervals; exine thickness 1.5 to 2μ; size about 42μ.

Illustrated specimen: United Clay Mines, slide 1, 87.1 × 4.0.

Remarks: The dispersed spore conforms in size and ornamentation to the associated spore illustrated and described by Couper from his study of Seward's type slide of *Ruffordia goepperti*. The difference between the dispersed and associated status suggests the new combination.

Family CHEIROPLEURIACEAE?
Genus DICTYOPHYLLIDITES Couper, 1958

Dictyophyllidites harrisii Couper
Plate 1, figure 3

Description: Trilete; laesurae long, reaching equator, on distinct ridges bordered by margo; equatorial contour triangular-convex; exine psilate, about 1μ thick; size about 34μ.

Illustrated specimen: Hammond well, 5104–12 ft., slide A, 103.8 × 5.1.

Remarks: Although Couper reports this species only from the Jurassic, it is not uncommon in the Cretaceous of Maryland and Delaware. The specimens found appear to fit Couper's description very well, except that they are slightly smaller.

FILICALES – INCERTAE SEDIS
Genus TRILOBOSPORITES Pant ex R. Potonié, 1956

Trilobosporites apiverrucatus Couper
Plate 2, figure 2

Description: Trilete; laesurae about two-thirds of diameter of grain; equatorial contour triangular-concave; exine coarsely verrucate at the apices of the grain with individual dome-shaped projections about 2μ wide and 1.7μ high; size range considerable, but average size about 50μ.

Illustrated specimen: United Clay Mines, slide 1, 9.2 × 17.7.

Remarks: Although the grains are somewhat smaller than those reported by Couper, they appear to be comparable in all other respects.

Genus PILOSISPORITES Delcourt and Sprumont, 1955

Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont
Plate 1, figure 6

Description: Trilete; laesurae two-thirds of diameter of grain, bordered by a margo; equatorial contour triangular, slightly concave; exine 2.5μ thick, with spines 5 to 7μ high and 2μ wide at their base; size 62μ.

Illustrated specimen: Hawkins Point, slide 3a, 90.5 × 22.9.

Remarks: Only a few specimens were found, but they are well preserved and could be easily identified.

SPORES–INCERTAE SEDIS
Genus DENSOISPORITES Weyland and Krieger, 1953

Densoisporites perinatus Couper
Plate 1, figure 5

Description: Trilete; laesurae indistinct, if visible about two thirds of diameter of grain; equatorial contour triangular-convex to circular; a perine 5 to 7μ wide surrounds the spore; size about 55μ.

Illustrated specimen: Hammond well, 5130–35 ft., slide A, 91.0 × 0.9.

Remarks: This spore appears to fit Couper's description perfectly and is therefore considered to be the same species.

Genus CINGULATISPORITES Thomson, 1953

Cingulatisporites psilatus Groot and Penny, **new species**
Plate 2, figure 21

Description: Trilete; laesurae long, extending into the cingulum, on ridges, equatorial contour triangular with broadly rounded apices; cingulum 5 to 8μ wide; exine psilate, nearly 2μ thick; size about 46μ.

Holotype: United Clay Mines, slide 1, 91.0 × 6.1.

Remarks: This species is very similar to *C. valdensis* described by Couper (1958), except for the lack of ornamentation.

GYMNOSPERMAE
CYCADALES and GINKGOALES (tentative assignment)
Genus MONOSULCITES Cookson ex Couper, 1953

Monosulcites minimus Cookson
Plate 2, figure 18

Description: Monocolpate; prolate; colpus long, from pole to pole, usually open at poles and closed at equator; grains pointed at poles; exine about 1μ thick, psilate or faintly scabrate; size about 32 × 18μ.

Illustrated specimen: United Clay Mines, slide 1, 85.1 × 4.1.

Remarks: The grains found in the nonmarine Cretaceous sediments of Delaware and Maryland appear to fit the description given by Couper (1958), and are therefore assigned to *M. minimus*. However, they have few good diagnostic features and they could possibly belong to another species.

Couper mentioned *Monosulcites* under the heading Incertae sedis, but speculated concerning their affinity to the Ginkgoales and Cycadales. The colpus, closing at the equator and open at the ends of the grain, points to such an affinity. Wodehouse (1935) described the same characteristic feature for the living Cycadales (p. 235).

CONIFERALES
Family TAXODIACEAE or CUPRESSACEAE
Genus INAPERTUROPOLLENITES
Pflug and Thomson, 1953

Inaperturopollenites hiatus (R. Potonié)
Pflug and Thomson
Plate 2, figure 19

Description: Inaperturate; spherical, grain split open; exine psilate, thin, about 1μ; size about 35μ.

Illustrated specimen: United Clay Mines, slide 1, 81.9 × 3.2.

Remarks: The grains assigned to *I. hiatus* have few characteristic features except their split exine. They appear to be similar to the grains described by Thomson and Pflug from the Tertiary of Europe, and are of little stratigraphic significance.

Family PINACEAE
Genus ABIETINEAEPOLLENITES R. Potonié, 1951

Abietineaepollenites grandialatus Groot and Penny, **new species**
Plate 1, figure 7

Description: Disaccate; length and breadth of body about equal, 56μ; bladders large, clearly reticulate; body scabrate; proximal cap well developed; overall breadth of grain about 85μ.

Holotype: Baltimore Brick Co., slide 2b, 98.3 × 17.7.

Remarks: This species is morphologically so similar to the pollen grains of some modern *Pinus* species that there can be little doubt as to its affinity.

Abietineaepollenites microreticulatus Groot and Penny, **new species**
Plate 1, figure 8

Description: Disaccate; body about 75μ long and 60μ wide; bladders large, about 75μ in length and 42μ in breadth; bladders finely reticulate (2 to 4μ mesh); overall breadth of grain about 95μ, length about 75μ.

Holotype: United Clay Mines, slide 1, 80.2 × 14.8.

Remarks: This species has the characteristic features of *Picea*, with the absence of a proximal cap, and the lack of a distinct angle between body and bladder.

Abietineaepollenites parvus Groot and Penny, **new species**
Plate 2, figures 1, 3

Description: Disaccate; breadth of body greater than length; bladders relatively small, clearly reticulate with

a mesh of 2 to 4μ; body scabrate; proximal cap 1 to 2.5μ; length of body about 40μ, breadth 48μ; length of bladders about 35μ, breadth 28μ. Overall breadth about 60μ, length 40μ.

Holotype: Hawkins Point, slide 4b, 103.7 × 4.8.

Remarks: This species can probably be referred to the genus *Pinus*.

CONIFERALES–INCERTAE SEDIS
Genus INAPERTUROPOLLENITES
Pflug and Thomson, 1953

Inaperturopollenites dubius Potonié and Venitz
Plate 2, figures 16–17

Description: Inaperturate; spherical or ellipsoidal; exine very thin, about 0.5μ, psilate or indistinctly scabrate, usually strongly folded; size about 35μ.

Illustrated specimen: United Clay Mines, slide 1, 77.1 × 3.8.

Remarks: This species has few morphological characteristics and may represent several genera of plants. Most likely it belongs to one or more conifer genera.

ANGIOSPERMAE–INCERTAE SEDIS
Genus TRICOLPOPOLLENITES Potonié, 1934

Tricolpopollenites crassimurus Groot and Penny, **new species**
Plate 2, figures 4, 5

Description: Tricolpate; grain oval in equatorial view, prolate; colpi distinct, 19μ long; exine scabrate, about 1.2μ thick; size about 28 × 22μ.

Holotype: Hawkins Point, slide 2b, 72.8 × 107.0.

Remarks: These grains fall within the range of variation of modern *Quercus*. They also bear some similarity to *Tricolpopollenites asper* Pflug and Thomson.

Tricolpopollenites micromunus Groot and Penny, **new species**
Plate 2, figures 6, 7

Description: Tricolpate; nearly isodiametric, usually obliquely compressed; colpi distinct, robust, about 10μ long; exine relatively coarsely reticulate; size about 14μ.

Holotype: Hawkins Point, slide 2b, 62.1 × 108.0.

Remarks: Somewhat similar, except for size, to *Tricolpopollenites retiformis* Pflug and Thomson.

Tricolpopollenites parvulus Groot and Penny, **new species**
Plate 2, figures 8, 9

Description: Tricolpate; grain about isodiametric, usually seen in polar view; colpi short; exine psilate, about 1μ thick; size about 13μ.

Holotype: Hammond well, 1668–78 ft., slide 2, 57.5 × 117.

Remarks: Some morphological similarity to *Tricolpopollenites liblarensis* (Thomson) Pflug and Thomson.

Genus TRICOLPOROPOLLENITES R. Potonié, 1931

Tricolporopollenites subobscurus Groot and Penny, **new species**
Plate 2, figures 12, 13

Description: Tricolporate; grains nearly isodiametric; colpi 12μ long; pores about 3μ in diameter, weakly developed; exine finely reticulate, about 1.5μ thick; size about 21μ.

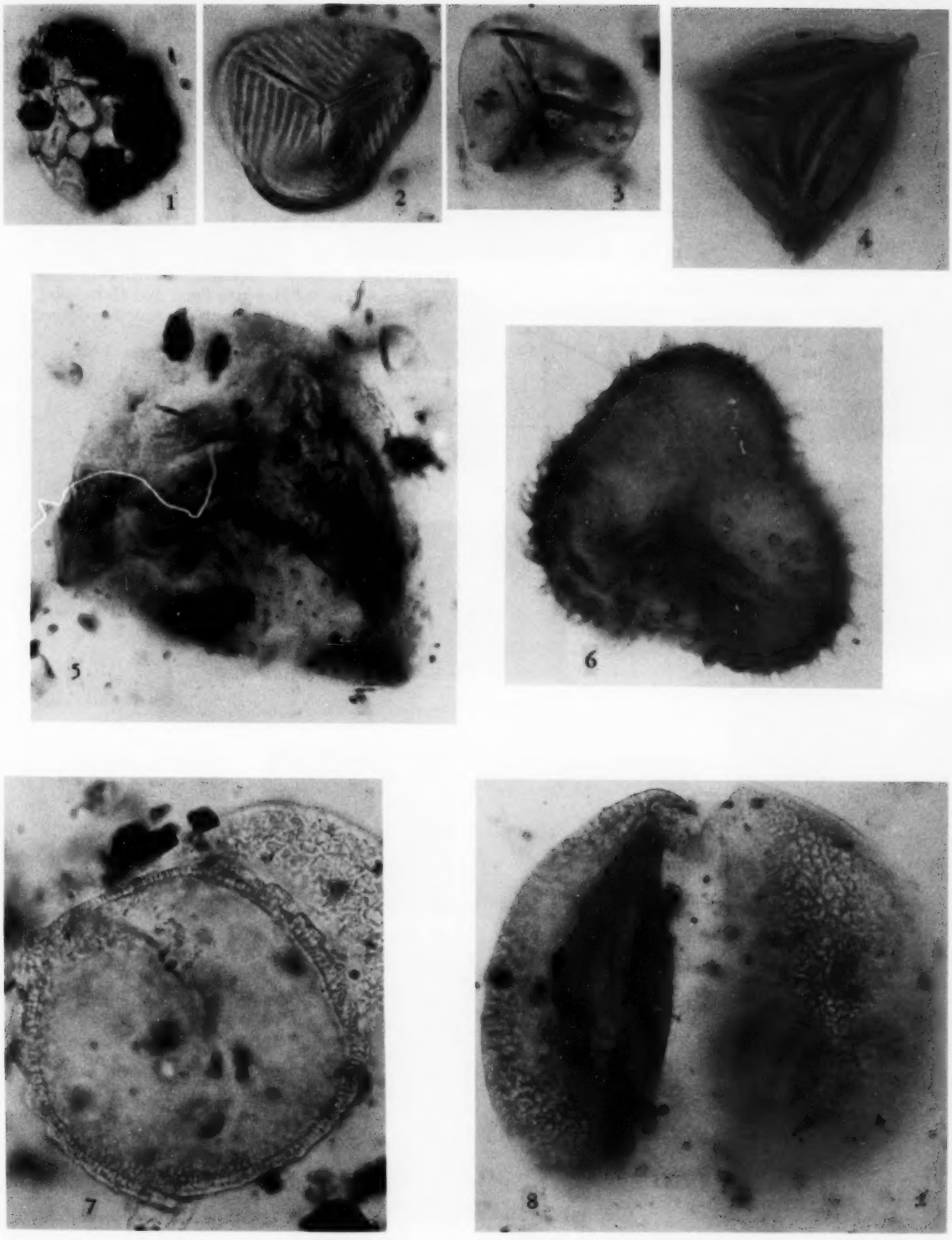
Holotype: Edgewood, slide 2c, 61.3 × 103.7.

Remarks: Somewhat similar to *Tricolporopollenites microreticulatus* (Thomson) Thomson and Pflug.

PLATE 1

All magnifications are × 1000

1 *Lycopodiumsporites clavitoides* Couper
2 *Cicatricosisporites dorogensis* Potonié and Gelletich
3 *Dictyophyllidites harrisii* Couper
4 *Appendicisporites tricornitatus* Weyland and Greifeld
5 *Densoisporites perinatus* Couper
6 *Pilosisporites trichopapillosus* (Thiergart) Delcourt and Sprumont
7 *Abietineaepollenites grandialatus* Groot and Penny, n. sp.
8 *Abietineaepollenites microreticulatus* Groot and Penny, n. sp.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Tricolporopollenites distinctus Groot and Penny, **new species**
Plate 2, figure 10

Description: Tricolporate; prolate, colpi long and distinct; pores about 2μ in diameter, circular; no transverse furrow; exine psilate, 1μ thick; size 13 × 10μ.

Holotype: Tidewater Oil Company well no. 12, 275 ft., slide A, 103.5 × 8.5.

Tricolporopollenites planus Groot and Penny, **new species**
Plate 2, figures 11, 15

Description: Tricolporate; equatorial contour circular, grains usually flattened and seen in polar view; colpi fairly long leaving only a small polar area; pores weakly developed, about 3μ in diameter; exine distinctly scabrate, 1.5μ thick; size about 25μ.

Holotype: Hawkins Point, slide 4b, 107.6 × 15.8.

POLLEN – INCERTAE SEDIS
Genus EUCOMMIIDITES (Erdtman) Couper, 1958

Eucommiidites minor Groot and Penny, **new species**
Plate 2, figure 14

Description: Tricolpate(?); nearly isodiametric; one colpus wide and well developed, the other two colpi(?) relatively narrow; colpi(?) short, about one half of diameter of the grain; exine psilate, nearly 2μ thick; size approximately 25μ.

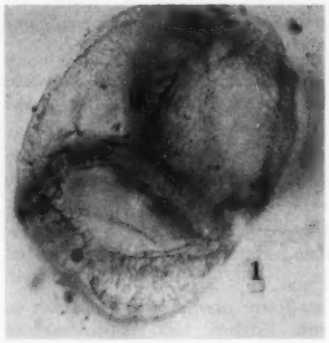
Holotype: Hawkins Point, slide 4b, 98.2 × 1.2.

Remarks: Mr. N. F. Hughes of the Sedgwick Museum, Cambridge, England, recognized the occurrence of *Eucommiidites* in the Hawkins Point and Hammond well material. Because these grains are smaller than those found in the Wealden of England, Mr. Hughes suggested that it be named *Eucommiidites minor*. The authors have seen too few specimens of *Eucommiidites* to express an opinion as to its angiospermous origin.

PLATE 2

All magnifications are × 1000

1 *Abietineaepollenites parvus* Groot and Penny, n. sp.
2 *Trilobosporites apiverrucatus* Couper
3 *Abietineaepollenites parvus* Groot and Penny, n. sp.
4 *Tricolpopollenites crassimurus* Groot and Penny, n. sp.
5 *Tricolpopollenites crassimurus* Groot and Penny, n. sp.
6 *Tricolpopollenites micromunus* Groot and Penny, n. sp.
7 *Tricolpopollenites micromunus* Groot and Penny, n. sp.
8 *Tricolpopollenites parvulus* Groot and Penny, n. sp.
9 *Tricolpopollenites parvulus* Groot and Penny, n. sp.
10 *Tricolporopollenites distinctus* Groot and Penny, n. sp.
11 *Tricolporopollenites planus* Groot and Penny, n. sp.
12 *Tricolporopollenites subobscurus* Groot and Penny, n. sp.
13 *Tricolporopollenites subobscurus* Groot and Penny, n. sp.
14 *Eucommiidites minor* Groot and Penny, n. sp.
15 *Tricolporopollenites planus* Groot and Penny, n. sp.
16 *Inaperturopollenites dubius* Potonié and Venitz
17 *Inaperturopollenites dubius* Potonié and Venitz
18 *Monosulcites minimus* Cookson
19 *Inaperturopollenites hiatus* (R. Potonié) Pflug and Thompson
20 *Cicatricosisporites goepperti* Groot and Penny, new combination
21 *Cingulatisporites psilatus* Groot and Penny, n. sp.
22 *Cicatricosisporites goepperti* Groot and Penny, new combination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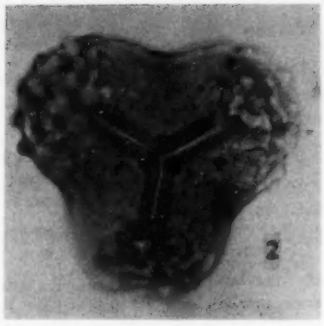
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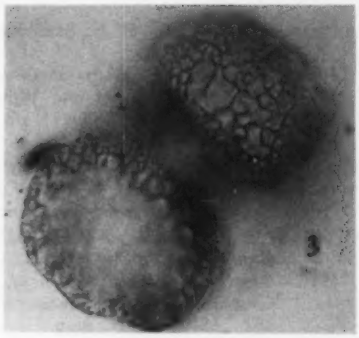
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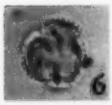
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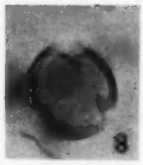
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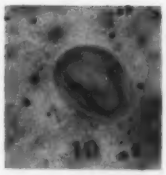
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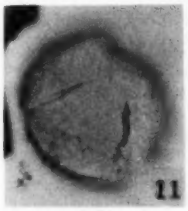
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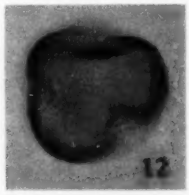
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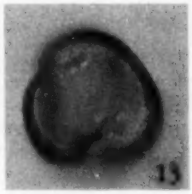
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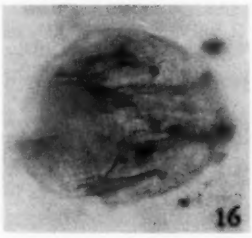
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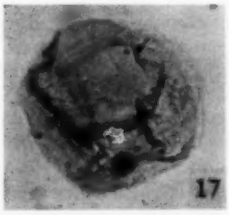
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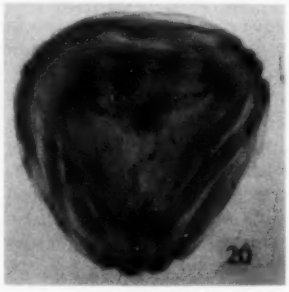
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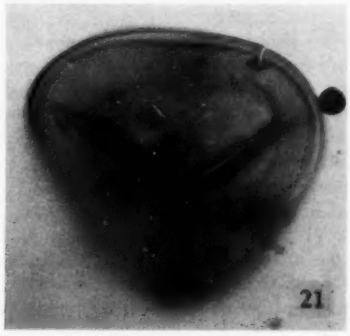
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ABSTRACT: *A quick and simple method of preparing permanent slides of plant microfossils on cover-glasses for immediate examination is described.*

Double cover-glass slides for plant microfossils

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INTRODUCTION

Double cover-glass slides, containing plant microfossil material in a very thin layer of Canada balsam have been used successfully at the Coal Geology Laboratory of the U. S. Geological Survey in Columbus for about four years. They have several advantages if standard methods for quantitative comparison of fossil elements are needed. Their advantages are: permanency, ease of preparation, and immediate use for examination from either top or bottom. The publication of this method was authorized by the Director of the U.S. Geological Survey.

TECHNIQUE

The usual preparation method for separation of plant microfossils of organic composition from sedimentary rocks involves disaggregation, maceration, and concentration of microfossils by flotation on a heavy liquid (Grichuk, 1939; Knox, 1942; Norem, 1953, 1956). Soviet paleontologists have often used Thoulet's solution, but mixtures of bromoform and alcohol, slightly exceeding 2.0 specific gravity, have been more commonly used here. Kurtz and Turner described an oil flotation procedure in 1957. In some instances it is practical to dissolve most of the mineral matter in hot hydrofluoric acid and dispense with heavy liquid flotation. Such a procedure is not practical if there is a low concentration of microfossils, and if a substantial volume of material must be processed. Whether or not a heavy liquid is used, treatment in strong reagents necessitates a thorough and repeated washing of the residue. Usually this repetitive washing is terminated in water if one intends to use a water soluble mounting medium. Less work and smaller amounts of additional reagents are required, however, if final stages are completed in a medium compatible with balsam. Originally, the residue washing was finished in xylol for this reason. In later work commercial grade butyl cellosolve (ethylene glycol monobutyl ether; $CH_2OH_2 \cdot CH \cdot O \cdot C_4H_9$) has replaced xylol because of its tolerance to water, good storage properties, suitability as a vehicle for safranin stain, and its solvent properties with Canada balsam. Residues dispersed in butyl cellosolve are transferred, as standard procedure, directly into 1 or 3 dram flat-bottomed vials for preparation of slides at any time, and for storage (text-fig. 1). Slide preparation begins with dispersed macerated material, more or less stratified by settling, at the bottom of a flat-bottomed vial.

Microfossils and associated carbonaceous materials occupy more apparent volume in the vials than they did in the rock. Nevertheless, the expansion probably is roughly comparable from one residue to the next, so that a proportional adjustment of the volume of total carbonaceous residue can be compared with the volume of rock originally treated. Moreover, if materials in the residue in the storage vial are proportionately represented on slides, the actual concentration of any class of material, or any particular type of microfossil, can also be determined. A transect method, such as that in which the Whipple disc is used in coal microscopy (Schopf, 1956), seems feasible. Necessarily, the results of such determinations are volumetric. Volumetric units are probably more suitable for comparisons of fossil concentration than gravimetric units, because of the variations in density of minerals and the inordinate contrast between minerals and "organic" microfossils, or similar associated materials. Since concentration of microfossils and of particular kinds of microfossils in sedimentary rocks, as well as the relative proportions of fossils of the assemblage, has a geologic and paleoecologic significance (Muller, 1959), accuracy in sampling the total residue and in proportional representation of materials on the microslides is of interest. The slide preparation procedure to be described is suitable for this purpose.

SAMPLING OF RESIDUES

Sampling of residues in the vials is carried out by use of a glass sample tube (text-fig. 2). The open tube should be pressed through the sample to the bottom of the vial and the other end covered with a finger tip. A uniform core sample of residue material can then be withdrawn. The core sample may be cleanly transferred to a Syracuse watch glass by flushing the tube with a few drops of butyl cellosolve from a polyethylene wash bottle. For most accurate sampling results the residue adherent to the outside of the tube should be washed back into the storage vial since it probably does not include a proportional cross section of the residue. Experience will show what size watch glass sample is most appropriate. The size of sample can be regulated by using sample tubes of different diameter or by taking two or more cores of material from the storage vial. The contents are scarcely disturbed if successive cores are taken from opposite sides of a storage vial.

The small quantity of sample in the watch glass may be stained, if desired, and then introduced into concentrated balsam by removal of the solvents (text-fig. 3). This can be performed in essentially a single operation by adding reagents in the watch glass and by removing solvents by evaporating on a warming plate. A few drops of stain, usually a dilute solution of safranin in butyl cellosolve, may be added to the sample in the watch glass. Very little stain is needed, and, if an excess is present, it will precipitate as the balsam becomes concentrated. If this should happen, the balsam should be redissolved in butyl cellosolve and additional balsam and sample added before reconcentrating, to reduce the ultimate concentration of safranin. There is a considerable range of tolerance for good results, however, and this difficulty is easily avoided. A small amount of biological grade Canada balsam (purified fluid balsam dissolved in xylol) is added and thoroughly mixed with the sample in butyl cellosolve in the watch glass. The amount of balsam needed depends on the quantity of sample and the final concentration that is found desirable. Concentration of fossils can always be reduced by mixing the sample with additional concentrated balsam.

If the warming plate is kept at 80–100° C, nearly all the solvents should be driven off in an hour or less, depending on the amount of solvent to be removed. Although the solvent has no strong odor and fumes from one or two sample dishes are not ordinarily objectionable, continued exposure of laboratory personnel to butyl cellosolve fumes is inadvisable. If many samples are to be prepared, evaporation should be carried out with positive ventilation in a fume hood. The sample should be occasionally stirred to insure good mixing with the balsam. Flat toothpicks whose ends are nipped off obliquely can be used as convenient individual stirring implements, one for each sample. The toothpicks also serve as a convenient means of distributing a suitable amount of the balsam concentrate to cover-glasses, with included fossil material, for preparing the double cover-glass slides.

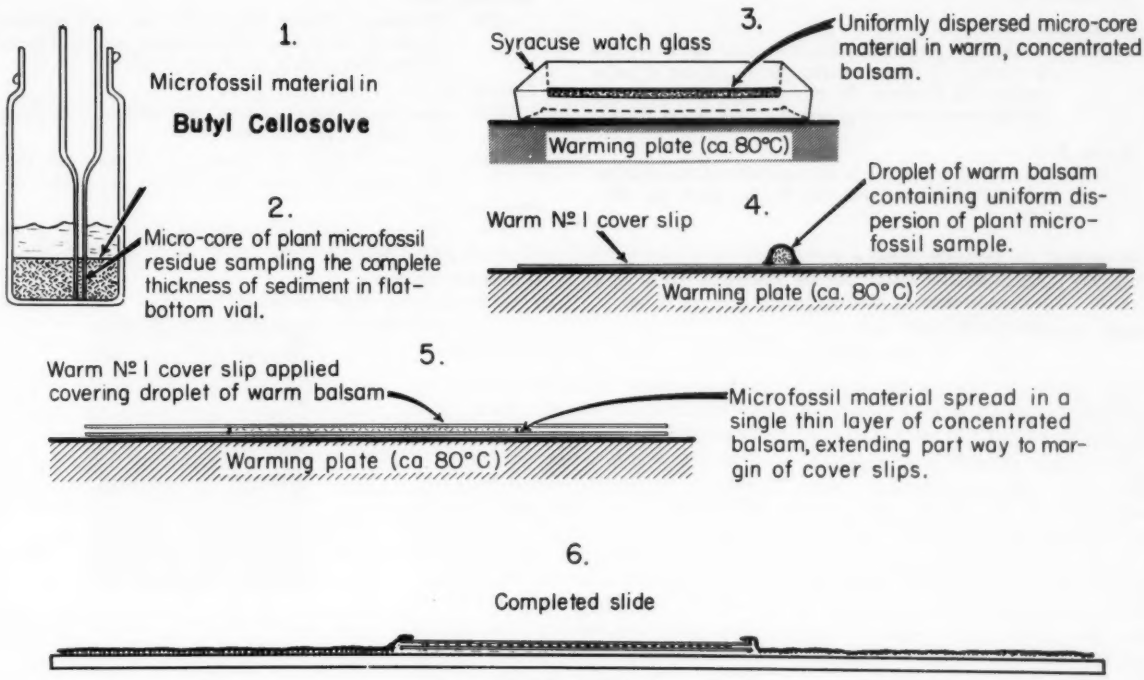
After the warm balsam becomes somewhat viscous, a droplet of this material is placed on a warm cover-glass (text-fig. 4) placed alongside the watch glass on the warming plate. No. 1 cover glasses, 25 mm. square, are recommended. A second warm cover-glass, the same size as the first, is then placed on top of the droplet of material and the droplet allowed to spread between the two cover-glasses (text-fig. 5).

For best results the material should *not* reach to the margins of the two covers, after it has spread, but should stop short. However, it is most important that the fossil specimens be properly dispersed and that the film of balsam with fossils be very thin. Only a small droplet of material is required if the slide is reduced to proper thickness and if loss of material at the edges is to be avoided. Pollen analysts have noted the tendency for certain kinds of pollen grains to be more abundant towards the edges of micropreparations. In other words, a certain type of segregation can occur in preparing slides which may distort determinations of relative abundance. If none of the material spreads to the margin and none is lost, a transect of both marginal and central areas should provide for accurate proportional representation.

The thickness of the preparation is ordinarily determined by the thickness of the coarsest particles of the sample. For this reason it is often advisable to check the sample under the microscope soon after it is placed in the watch glass, before balsam is added or solvents evaporated, so that any unusually coarse particles can be removed. This procedure also reduces the occasional danger of particles that could crack a cover-glass. It will also permit an experienced observer to make a preliminary evaluation of the quality of a residue. If the balsam has been concentrated to high viscosity before transfer to cover-glasses, it may be necessary to press lightly on the top cover-glass to spread the material evenly. It is also feasible to expedite spreading by placing cover-glass slides in a warmer position on the warming plate. Thick preparations should always be avoided by whatever measures are necessary. In properly prepared thin preparations, most of the flattened fossils are oriented horizontally in a favorable position for observation and identification.

After spreading, the cover-glass slides can be picked up by tweezers and then, by holding them on the edges, the two cover-glasses can be slipped laterally until they are in accurate register. This must be done promptly because, being very thin, the slides cool rapidly. When cool, the balsam should have become hard enough that the preparation is essentially solidified and fossils cannot be displaced. Such slides are now permanent mounts, ready for examination or for storage.

Solidification in finished slides is most effectively tested under the microscope by pressing on the top cover glass with a needle while observing whether any fossils move. If any fluid movement is observed, it suggests that not


1.
Microfossil material in
Butyl Cellosolve
2.
Micro-core of plant microfossil residue sampling the complete thickness of sediment in flat-bottom vial.
3.
Syracuse watch glass
Uniformly dispersed micro-core material in warm, concentrated balsam.
Warming plate (ca. 80°C)
4.
Warm Nº 1 cover slip
Droplet of warm balsam containing uniform dispersion of plant microfossil sample.
Warming plate (ca. 80°C)
5.
Warm Nº 1 cover slip applied covering droplet of warm balsam
Microfossil material spread in a single thin layer of concentrated balsam, extending part way to margin of cover slips.
Warming plate (ca 80°C)
6.
Completed slide

TEXT-FIGURES 1–6

enough solvent had been evaporated before slides were prepared. On the other hand, if the balsam has been hardened excessively, a sharp blow can loosen one cover glass or the other from the preparation. It is not at all difficult, however, to obtain suitable preparations with fossils immobilized and with the balsam showing all of the excellent keeping qualities for which it is most noted.

Cover-glass slides should be affixed to a standard 1 × 3 inch glass slide, or some other type of holder, for labeling and ease in handling. For locating particular fossils an index mark like that advocated by Traverse (1958) can be used on one cover glass surface, or selected specimens can be marked with dots of India ink.

The writer has experimented with a variety of slide holders and finally concluded that it is most satisfactory simply to tab the edges of cover-glass slides in the center of a standard 1 × 3 inch slide, by use of smooth surface, pressure adhesive, masking tape (text-fig. 6). The masking tape takes ink well and can be readily obtained in 1 inch widths to correspond with slides. The pressure adhesive may alter with age but, in the course of experience of a few years of this application on slides, its deterioration has not been noted. At any rate, it can be renewed readily. Most importantly, however, it can be loosened from the cover slip edges whenever desired and the cover-glass slides turned over for direct study of the reverse surface of any fossil. If cover-glass slide holders were needed in quantity, several designs might be suggested that would probably serve the purpose equally well or better. However, standard glass slides have the advantage of being generally available in suitable quantities, and of lying flat and fitting to a mechanical microscope stage better than most metal devices that can be made in the laboratory.

Following slide preparation, the concentrated residue in balsam in the watch glasses is redissolved in butyl cellosolve. The dissolved balsam and remaining residue is decanted back into the storage vial from which the sample originally was taken. When balsam thus is introduced into the storage vial, it eliminates any need for concern about later evaporation of the storage solvent. Residues in reserve storage always tend to dry out. With balsam present, a dried-out old residue can always be redispersed for subsequent studies. After the redissolved balsam with its residue has been poured back into a storage vial, the watch glasses can be cleaned easily for reuse by wiping with a towel moistened with xylol, followed by the normal soap and water washing for laboratory glassware.

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ARGENTINA

ESTEBAN BOLTOVSKOY

The following account covers the activities of the micropaleontologists of Argentina and Uruguay. As usual I shall arrange my report according to groups of organisms discussed.

Fossil foraminifera

Dr. H. Comacho (Universidad de Buenos Aires) returned from the United States in February, 1959, where he stayed for a year on a J. S. Guggenheim Memorial Foundation Fellowship. He studied for five months in the U. S. National Museum, Washington, D. C. paying particular attention to the Eocene foraminifera collected in Tierra del Fuego. This study is now being prepared for the press and will be published in the near future under the title, "Foraminiferos Eocenos de Tierra del Fuego," in one of the Argentine scientific journals.

At present Dr. Comancho is occupied in teaching micropaleontology in the Geological Faculty of the University of Buenos Aires. A number of students in their final university year have become much interested in the micropaleontological sciences and it is to be hoped that new strength will be infused into our small group of Argentine micropaleontologists.

Recent foraminifera

It is of considerable interest to note here that Dr. M. C. Müller-Melchers (Museo de Ciencias Naturales, Montevideo, Uruguay) accidentally found an excellently preserved specimen of silicious foraminifera, *Silicotextulina deflandrei*, while making an examination of diatoms in a plankton sample. The sample came from near Abrolhos Bank in Brazilian waters, and yielded the third specimen of this very rare and interesting species found in the Atlantic Ocean. The two other examples are from Quequen and Cuba.

Your correspondent published the following four papers during the past year: "On the organization of the foraminiferal collection," Contr. Cushman Found., vol. 9, pp. 99–102, 1958; "Recent foraminifera of southern Brazil and their relation with those of Argentina and the West Indies", Secr. Marina, Serv. Hidrogr. Naval, no. 1005, pp. 1–124, pls. 1–20, 1959; "Foraminifera as biological indicators in the study of ocean currents", MICROPALEONTOLOGY, vol. 5, no. 4, pp. 473–477, pls. 1–3 1959; and "La corriente de Malvinas," Secr. Marina, Serv. Hidrogr. Naval, no. 1015, pp. 1–96, pls. 1–3, maps, 1959. The last work is devoted entirely to the Malvin current (Falkland Islands), the history of its investigation, its geological origin, biological indicators (foraminifera), termination and limits. It is published in Spanish, but has ample summaries in English and German. All persons interested in obtaining this publication, as well as that on the Recent Brazilian foraminifera cited above should address their request as follows: Sr. Bibliotecario (Librarian), Servicio de Hidrografia Naval, Av. Montes de Oca No 2124, Buenos Aires, Argentina.

As is well known, the First International Oceanographic Congress, organized by the American Association for the Advancement of Science took place in New York City from August 30 through September 12. Your correspondent attended its session and participated in its proceedings by presenting and reading a paper. It was a great pleasure to meet many old friends and colleagues, whom I first met on my previous visit two years ago. I also had the pleasure of seeing many other co-workers who came from many countries overseas to attend the Congress. I remained three weeks in the United States after the Congress was over to work and to visit some of the research institutions. I was very kindly received everywhere, for which I take this opportunity of expressing my warm appreciation.

It is a great pleasure to announce at last that micropaleontological study is to be employed in oil exploration in Argentina. Shell Production Company of Argentina, Ltd. has signed a contract with the Argentine Government for oil drilling in the south of the Province of Buenos Aires and the eastern part of the Province of Rio Negro. The organization of the micropaleontology laboratory is now being finished, with Dr. J. P. H. Kaasschieter from Utrecht, the Netherlands, coming as specialist on the foraminifera. He will have but one assistant, but it is hoped that his staff will be increased as the volume of work is large. Dr. Kaasschieter is anxious to have a good library and would appreciate it greatly if his

colleagues would send him foraminifera literature. His address is: Shell Production Company of Argentina, Ltd., Maipu 215, Buenos Aires, Argentina.

Ostracoda

Dr. H. Camacho, during his trip to the United States, spent four months at the University of Louisiana studying the Tertiary Ostracoda from Patagonia under the direction of Dr. Henry Howe. The results of this investigation are almost ready for press and will be published under the title: Ostracoda dos Terciarios de Patagonia.

Dr. H. A. Orlando (Universidad de Bahia Blanca), in collaboration with Dr. J. U. de De Carli, has begun a study of the ostracodes from the Weddell Sea, Antarctica.

Diatoms

Dr. J. Frenguelli, deceased in 1958, and Dr. H. Orlando published a joint work, "Diatomeas y Silicoflageladoa de Sector Antártico Argentino," Publ. no. 5, Inst. Antart. Argentino, pp. 1–155, pl. 1–17, 1958, and a paper, "Analysis de algunas muestras del Pleistoceno del fondo del mar Mediterraneo, enviadas por el Lamont Geological Observatory," Secr. Marina, Serv. Hidrogr. Naval, no. 1014, pp. 1–7, 1959. The former work are the results of study of rich material collected on four Antarctic expeditions. It contains maps and many excellent illustrations and photographs of the specimens. A total of 293 species of diatoms are described, of which 29 are new. In addition, one new species of silicoflagellate is described. This publication is a very valuable work for the student of diatoms, both Recent and fossil.

Dr. Orlando also has published a work entitled "Sintesis general de orden biologico" in a special collection devoted to the investigations resulting from the Argentine Antarctic expedition of 1958–1959, Secr. Marina Serv. Hidrogr. Naval, no. 606, pp. 21–31, 1959. In addition, Dr. Orlando has in press two papers: "Diatomeas and Silicoflagelados de la VI campaña Merluza" and "Informe acerca del plancton del II crucero Drake." At present he is continuing his study of diatoms and silicoflagellates of the Antarctic waters, particularly of the Weddell Sea, Drake's Passage and the southern part of the south Atlantic Ocean.

Dr. F. C. Müller-Melchers has published a paper, "Plankton diatoms of the southern Atlantic Argentina and Uruguay coasts," Comun. Bot., no. 38, vol. 3, Museo de Historia Natural de Montevideo, pp. 1–45, pls. 1–4, 1959. He describes more than 100 species of which one is new. The study is very interesting as it offers new data on the diatoms as biological indicators. In this case it discusses the sub-antarctic diatoms displaced by the Malvin current. Another work by Dr. Müller-Melchers is "Plankton diatoms of the 'Toku-Mar' voyage, Brazil coast," Bol. Inst. Oceanogr., Univ. Sao. Paulo, vol. 8, nos. 1, 2, pp. 111–125 pls. 1–6, 1957. This covers the study of 18 plankton samples taken by the Japanese fisheries research ship in 1957 between latitudes 5°N and 2°S, not far from the Brazilian coast. Eighty species were recovered, of which two are new.

Dr. Müller-Melchers made two visits of six months each to the Institution of Sao Paulo, Brazil. He studied Recent diatoms and gave a course on diatoms. Dr. Müller-Melchers has finished his manuscript on the diatoms from Cuban waters. He submitted it to the Catholic University of Cuba for publication, but apparently recent political events have postponed its appearance. In 1960, Dr. Müller-Melchers will return to the Oceanographic Institution of Sao Paulo for six months of study.

In connection with Recent diatoms, Dr. Hugo J. Ferrando, of Montevideo, began his study of Recent forms a short time ago under the encouragement and supervision of Dr. Müller-Melchers. As a result of his deep interest and industry in the subject he has produced five papers: "Técnica para el estudio de las Diatomeas," Bol. Inst. Oceanogr., Univ. Sao Paulo, vol. 7, no. 1, 2, pp. 151–160, 1956, co-author with Dr. Müller-Melchers; "Hipóthesis sobre productividad en el área biooceanográfica correspondiente a los litorales marítimos de Argentina, Uruguay y Sur de Brasil," ibid, vol. 8, no. 1, 2, pp. 225–240, 1957; "El empleo de los colorantes para el estudio citológico de las diatomeas," An. Fac. Veter., Univ. Montevideo, vol. 8, no. 6, pp. 19–34, 1958; "Red para fitoplancton con copo intercambiable," Cont. Avuls. Inst. Oceanogr., Univ. Sao Paulo, Oceanogr. Biol., no. 1, pp. 1–7, 1958; "Estudio del Plancton en la zona de pesca de la Merluza," An. Fac. Veter., Univ. Montevideo, vol. 8, no. 6. pp. 89–99, 1958. As we can see from the foregoing account, Dr. Ferrando's interest is not only in diatoms, but also plankton in general. At present he is conducting a class on diatoms at the University of Montevideo and also is preparing a manual devoted to the diatoms and their study to be used in teaching which he hopes to publish next year.

Spores and pollen

Dr. S. M. Archangelsky of the Universidad de Tucumán, who received a fellowship from the British Council, is in Great Britain making a study of some paleobotanical problems, including spores and pollen.

Plankton

Dr. E. Balech (Necochea, Prov. Buenos Aires) has studied the Recent plankton of Argentine marine waters for many years. He was awarded a J. S. Guggenheim Memorial Foundation Fellowship and spent 21 months in 1957–1959 in the United States, mostly at the Scripps Institution of Oceanography at La Jolla, California. He published the following four papers: "Plancton de la campaña Antartica Argentina 1954–1955," Physis, no. 60, pp. 75–108; "Dinoflagellés et Tintinnides de la Terre Adèlie (Secteur Français Antarctique, Missions Plaires Françaises de P. E. Victor), Vie et Milieu, vol. 8, no. 4, pp. 382–408; "Biooceanografiaj studoj en

Argentino (in Esperanto) Sciencaj Studoj, Kopenhagen; "Two new genera of Dinoflagellates from California," Biol. Bull., vol. 116, pp. 195–203, 1959.

Dr. Balech has two additional papers in press: "Operacion Merluza Plancton del Quinto Crucero" published by the Hydrographic Office and "Tintinnoidea del Mediterraneo" published by the Oceanographic Institute of Spain. As a result of his extensive investigations, Dr. Balech has concluded that the endemism of the Antarctic plankton is much more pronounced than was supposed. Aside from the many systematic problems connected with these organisms, the use of them as biological indicators for the different water masses also interests him. Dr. Balech is presently studying the plankton samples brought in by Argentine research ships in recent years. During the summer of 1959–1960 the Argentine ice-breaker, "Gral. San Martin," will go as usual to the Antarctic with Dr. M. J. Pizarro and Dr. L. A. Rossi, both of the Universidad de Buenos Aires, to make a study of the source of plankton in the Weddell Sea.

Other news

The first Latin American Zoological Congress was held in La Plata, Argentina, from October 12 to 24, 1959. About 350 delegates from ten Latin American countries attended. The total number of papers read and discussed was about 300. Unfortunately only a single paper was presented on microorganisms, that of your correspondent, before the Congress. A symposium on Antarctica was held in Buenos Aires from November 17–25, 1959. It took on an international character since all 12 countries which took part in the Antarctic studies during the International Geophysical Year sent their delegates. Many talks were given by those attending, including a conference on Antarctic diatoms by Dr. Orlando, and one by your correspondent on sub-antarctic foraminifera. The total number of delegates was 167, and the number of papers presented 181.

Only three students of foraminifera visited Buenos Aires and our Museum of Natural History during the period of the Antarctic symposium.

Dr. J. C. Troelsen and Mrs. Troelsen, of Belem, Brazil, visited the most interesting Cretaceous outcrops, in January 1959. He was awarded the Williams Foundation Fellowship (Argentina) for this task. Dr. D. Closs and Dr. M. Barberena from the Universidade do Puerto Alegre, Brazil, visited Argentina in June and July. These scientists wish to organize a new micropaleontology laboratory in their university and came in search of library material and equipment. Dr. Closs was here for only a few days, but Dr. Barberena stayed longer having brought some specimens on which to work in your correspondent's laboratory, using the literature and collections for comparisons. I remember with great pleasure the visits of all these colleagues.

ESTEBAN BOLTOVSKOY
Museo Argentino de Ciencias Naturales
Buenos Aires

AUSTRIA

RUDOLF GRILL

"Micropaleontology in Austria, Past and Present" is a study by H. Küpper (Geological Survey of Austria) as published in "Erdöl-Zeitschrift", Vienna 1959 (pp. 114–121). J. E. von Fichtel, E. K. von Moll, A. E. Reuss, F. Karrer, R. J. Schubert, V. Uhlig, Fr. Toula, to mention only a few of the best known names, contributed fundamentally to the development of micropaleontology. A stratigraphy based on foraminifera began to be outlined more systematically in the early thirties of this century in connection with intensified oil exploration. Bibliographies of Reuss, Karrer and Schubert and a list of outstanding papers after 1930 rounds out the study.

R. Oberhauser (Geological Survey of Austria) continued investigations in the Alpine Triassic. In his studies on the Upper Cretaceous he succeeded in establishing a Campanian level in the reefs with Rudistae of the "Gosau" (Alpine Upper Cretaceous) at Kainach in Styria, and in furnishing further evidence for the Turonian age of the Klement beds in the outer klippenzone (Waschberg zone) north of Vienna (Geol. Bundesanstalt, Verh., 1959, A 121). His report on the Rhätikon area in Vorarlberg contains hints for quick field determinations of Upper Cretaceous and Paleogene redbeds in the tectonically strongly disturbed deeper part of the Easter-Alpine nappes (Geol. Bundesanst., Verh., 1959, A 44).

S. Prey, A Ruttner, G. Woletz (Geological Survey of Austria) made a study on the Flysch "window" of Windischgarsten within the northern limestone Alps in Upper Austria (Geol. Bundesanst., Verh., 1959, pp. 201–216). Micropaleontology played an important part in establishing the Flysch character of the sediments involved because there are strong petrological similarities between Gosau and Flysch; likewise, heavy minerals helped to distinguish these rock units. Since the Flysch and Gosau often come into close contact tectonically, these means of diagnosis are highly useful.

The Flysch faunas of the Gault are very sparse, at times richer in radiolaria, but very poor in arenaceous forams and Globigerinae. The varicolored shales in the section above the Reiselsberg sandstone contain sparse, poorly developed arenaceous faunas with Dendrophryae; similarly, these also characterize the faunas of the overlying cement marl

series where they often occur together with stratigraphically more valuable forms, such as double-keeled Globotruncanae. The arenaceous faunas of the Flysch differ radically from those of the Gosau beds, which contain predominantly calcareous forms. The deeper lower Gosau beds are comprised of meager faunas with ostracodes and gastropods. In the higher parts there are calcareous faunas with Globotruncanae of Coniacian, Santonian as well as lower Campanian levels. The Nierental Schichten facies of the upper Gosau beds contain calcareous faunas of small-sized forms with Globotruncanae of the upper Senonian. Of great significance are two faunas of Globorotaliae and Hantkeninae which are determined as lower Eocene.

Dr. W. Klaus, palynologist of the Geological Survey of Austria, during the past year, dealt largely with the problem of the subdivision of the Alpine Triassic by means of spores. Four horizons are microfloristically well characterized. Further investigation showed that the Karnian stage can be clearly distinguished from the Norian stage (Geol. Bundesanst., Verh. 1959, pp. 160–163, 1 pl.)

Dr. Klaus has extended his investigations to the Hallstatt rock salt series, aiming at further subdivisions of this formation.

Dr. A. Papp of the Paleontological Institution of the University of Vienna is to be congratulated on his recently published book, "Tertiär, I. Teil, Grundzüge regionaler Stratigraphie" (Tertiary, part 1, Outlines of Regional Stratigraphy), 411 pages, 89 illustrations, 63 tables. It appeared as volume III in the series "Handbuch der Stratigraphischen Geologie" edited by Fr. Lotze, Ferdinand Enke, publishers, Stuttgart. In line with the constantly increasing stratigraphic significance of the microfossils, the latter, among them in particular the planctonic microforaminifera and the macroforaminifera, hold a prominent place in the conclusions of the author. The book emphasizes modern biostratigraphic working methods and the results thereby achieved, thus arriving at a new general picture based on biostratigraphy. This is in accordance with the editor's aim, *viz.*, to convey a concise representation of the vast abundance of new original literature. W. Klaus has contributed a separate chapter (C) to the book on palynology, stressing the stratigraphic possibilities in the Tertiary.

Dr. A. Papp discussed a nummulite fauna of lower Eocene age (lower Ypresian) from the Untersberg near Salzburg (Geol. Bundesanst., Verh. 1959, pp. 163–179, 10 illustrations). The red marls at the bottom of the nummulite-bearing beds are considered Paleocene because of the presence of Globorotaliae (Truncorotaliae) and Turborotaliae. The discoaster flora is in accordance with these results.

Dr. H. Stradner (Paleontological Institute of the University of Vienna) submitted a study entitled "First report on the Discoasters of the Tertiary of Austria and their stratigraphic use," to the Fifth World Petroleum Congress in New York. He is now preparing a more detailed report on the subject for publication.

At the meeting of the "Comitè du Néogéne Mediterranéen" held in Vienna July 10–18, 1959, under the direction of Prof. Dr. O. Kühn and Prof. Dr. J. Roger, several authors read important papers on the subdivision of the Neogene. On this occasion several excursions were arranged to visit the classic fossil localities of the Inner and Outer Alpine Vienna Basin. The latest micropaleontological investigations were used to explain the recently revised stratigraphic position of quite a number of these localities. There was ample opportunity to collect samples at type localities.

Prof. Vera Amsel, Technological Faculty of Zagreb University, is staying three months with the Geological Survey of Austria and the Paleontological Institution of the University of Vienna to make comparative micropaleonological studies.

RUDOLF GRILL
Geologische Bundesanstalt
Vienna

COLOMBIA

VIKTOR PETTERS

Servicio Geológico Nacional

The name of the Instituto Geológico has been changed to Servicio Geológico.

Dr. H. Buergl's micropaleontological activity has been reduced to routine determinations since most emphasis of the stratigraphic work is placed on the study of the Cretaceous of the Eastern Cordillera; these sediments are rich in mollusks but poor in foraminifera. Complete faunal lists and figures are given in "Biostratigrafía de la Sabana de Bogotá y sus alrededores" by H. Buergl, Boletín Geológico, Vol. 5, No. 2, 1957 (in Spanish with English abstract).

Dr. Thomas van der Hammen, head of the Pollen Section, left Colombia to become professor at the Geological Institute of the University of Leyden, Holland. During his stay in Colombia, since 1951, van der Hammen has done a very commendable job in setting up a detailed pollen stratigraphy of the widespread continental uppermost Cretaceous and Tertiary deposits. The petroleum industry which maintains only a few Pollen Laboratories in this country, is especially indebted to van der Hammen since most of the Colombian oil is produced from the continental Tertiary. Only a fraction of van der Hammen's results could be published as yet. Some have been briefly discussed in previous News Reports. The Boletín Geológico, vol. 5, No. 2, 1957 contains the following new papers: "Estratigrafía palinológica de la Sabana de Bogotá

(Cordillera Oriental de Colombia)" by Th. van der Hammen. It shows diagrams of pollen occurrence and distribution from the Maestrichtian to the middle Oligocene and correlates agewise some of the continental sediments of central Colombia and the Cauca Valley. In "Climatic Periodicity and Evolution of South American Maestrichtian and Tertiary Floras" (English and Spanish), published in the same number of the Boletín, the flora from the Maestrichtian to the Miocene is discussed and a pollen diagram given. Periodical changes on the flora at regular intervals of two and six million years are linked with evolution and climatic changes. A certain parallelism with orogenic movements and transgressions is seen. Unfortunately, a more detailed discussion of the stratigraphic results and the systematic description of the pollen species have not yet been published. Another unpublished report concerns the pollen of the two last Glacial (Pluvial) stages of the Sabana de Bogotá. A few conclusions are included in "Correlation between upper Pleistocene Pluvial and Glacial Stages," Geologie en Mijnbouw (n. ser.), 21e Jaargang, Feb. 1959 by G. G. Maarleveld and Th. van der Hammen. Another unpublished report in the files of the Servicio deals with the systematic collection of the pollen content of the air of the Sabana de Bogotá. The collections were made over a one year period at intervals of two weeks. Although Dr. van der Hammen's activity in Colombia came to an end, he will not bog down in the bogs of the polders of Holland. It was a pleasure to see him packing many voluminous boxes with Tertiary material from the Colombian Llanos, from Pleistocene swamp deposits of the lower Magdalena Valley, and from lake deposits of the Santa Marta mountains. The study of the latter material is intended to throw light on more recent climatic changes. It is sponsored by the Colombian committee of the Geophysical Year. During 1959, van der Hammen also studied the pollen of Pleistocene-Pliocene coastal deposits and of bauxite-bearing beds of British Guiana for the Colonial Geologic Survey.

Mrs. Nuria Sale de Porta is now in charge of the Pollen Section of the Servicio. She is studying the pollen of the marine Pliocene and Miocene of north coastal Colombia. This is part of a program to correlate the intermontane continental Tertiary studied by van der Hammen with the well dated marine sections of the coast. This will furnish a firmer basis for the rather tentative absolute age assignments given so far to the pollen zones of the Interior.

Mr. Enrique González from the Servicio received a scholarship of two years at the University of Leyden. He will be engaged in the description of Tertiary pollen from Colombia.

Colombian Petroleum Company

L. J. Shishkevich, formerly with Mobil of Colombia, is now with COLPET, after a prolonged stay in the States.

Empresa Colombiana de Petróleos

Palynological studies were commenced by the EMPRESA. They are conducted by Alfonso López and Raúl Cadena, graduates of the Universidad Nacional de Bogotá and former students of van der Hammen and Buergl.

International Petroleum (Colombia) Ltd.

C. G. Allen left Colombia and is now with Oasis Oil Company of Libya, J. A. McCormick was transferred to International in Talara, Perú, and your correspondent is now engaged in regional geologic work. R. Biel, A. C. Brookley, B. Hulsman and G. Olaya continue in the Bogotá lab.

Mobil Oil Company of Colombia

The laboratory was closed and L. J. Shishkevich is now with COLPET.

Richmond Petroleum Company

F. Pickett was transferred to Bolivia and Louis Martin was in charge of paleo until paleontological work was suspended late in 1959.

Concessionaria de Petróleos Shell-Condor

No changes in personnel from the previous News Report.

Texas Petroleum Company

The laboratory was closed down.

Miscellaneous

H. Buergl and M. Barrios opened a commercial paleontological laboratory in Bogotá as consultants on foraminifera, megafossils and pollen.

V. Petters
International Petroleum (Colombia) Ltd.
Bogotá

UNITED STATES—EAST COAST

RAYMOND C. DOUGLASS

U.S. National Museum

Dr. Richard Cifelli has joined the staff of the U. S. National Museum to work on foraminifera. Dr. Cifelli received his BA in geology at Montana State University in 1947, his MA in paleontology at the University of California in 1951, and his Ph. D. in geology at Harvard University in 1959. His Ph. D. thesis on the Bathonian foraminifera of England was published as a Bulletin of the Museum of Comparative Zoology, vol. 121, no. 7, p. 263–368, pl. 1–7, 1959. Dr. Cifelli came to the Museum from Brown University. He has spent three summers working in the field, and on the foraminifera in the collections of the U. S. Geological Survey. He also worked three and a half years with Phillips Petroleum during which time he was primarily engaged in paleontol-

ogic and stratigraphic studies of the Tertiary of the Pacific northwest. His current studies are on pelagic foraminifera from the Atlantic in cooperation with Woods Hole Oceanographic Institution, and on Jurassic foraminifera of the western interior of North America.

The following people made use of the collections of foraminifera and facilities of the U. S. National Museum during the period from November, 1958 to October, 1959: Esteban Boltovskoy, Buenos Aires, Argentina; R. Charmatz, New York University; B. Gonzales, Phillipine Islands; S. Hanzawa, Tohoku University, Sendai, Japan; M. H. Herrick, U. S. Geological Survey, Atlanta, Georgia; M. Leroy, Sociéte Africaine des Pétroles, Dakar; K. N. Sachs, Cornell University; E. Shifflet, Magnolia Oil Co., Dallas, Texas; J. H. Wall, Research Council of Alberta, Edmonton, Canada. In addition the following students of foraminifera visited the Museum: Zach Arnold, University of California; T. Barnard, University College, London; A. W. H. Bé, Lamont Geological Observatory, New York; Paul Bronniman, Esso Standard Oil, Cuba; E. Malarassi, Costa Rica; Nyi Nyi, University of Rangoon, Burma; E. Seibold, University of Kiel, Germany.

U.S. Geological Survey

Your correspondent had the delightful opportunity of spending six months between March and September 1959 in and around Santiago, Chile. The School of Geology of the University of Chile is now about two years old and wished to have a course in micropaleontology. I was privileged to start such a course for their fifth-year students and also ran a seminar on foraminifera for eight fourth-year students.

Knowing of no general text in Spanish on microfossils, I prepared a syllabus-type text covering methods, radiolaria, ciliata, foraminifera, ostracoda, spores and pollen, and diatoms. Each section is illustrated with line drawings. If anyone has a similar need, copies will probably be available from the School of Geology.

While in Chile, I was also able to collect fusulines at the southernmost occurrence known to date, from approximately 50° S in Magallanes Province of Chile.

The beautiful publication by Ruth Todd on foraminifera from western Mediterranean deep-sea cores was issued as Swedish Deep-Sea Expedition Reports., vol. 8, fasc. 2, no. 3 in December of 1958. In addition she and Paul Blackmon published a paper on the mineralogy of some foraminifera as related to their classification and ecology in the January 1959 issue of the Journal of Paleontology.

At the request of the U. S. National Museum, work on the fourth part of U. S. Nat. Mus. Bull. 161 on the Tropical Pacific collections of the *Albatross* is being completed for publication. This final part includes the rotaliform and the planktonic genera.

Miss Jean Berdan has been studying the types and topotypes of the ostracode genera *Beecherella* and *Scanthoscapha* from a collection made by C. E. Beecher from the Lower Devonian of Albany County, N. Y. A paper on this and a paper by Sohn and Berdan on the ostracode genus *Berounella*, based largely on specimens from the same collection, have been submitted to the Journal of Paleontology. Dr. Sohn is continuing the studies of ostracodes enumerated in an earlier report. Dayle Beldauf, one of the graduate students in the micropaleontology course started by Dr. Sohn at George Washington University, is preparing a masters thesis on some Paleocene ostracodes of Maryland.

Brown University

Martin Buzas is preparing his master's thesis on the study of near-Recent foraminifera from the postglacial marine clays exposed in Maine, which he expects to complete by June 1960.

Yale University

Professor Carl O. Dunbar retired from the University in June 1959, but is staying on at Peabody Museum to continue his work with the fusulines. With the help of Dr. Charles Ross, he will spend the year curating the large collection of fusulines in Peabody Museum, segregating and cataloguing all the types and completing research already under way on fusuline faunas from northeast Greenland, the Shibar Pass in Afghanistan, northern Sonora, and British Columbia.

Charles Ross has completed his study of late Pennsylvanian and early Permian (Wolfcampian) fusulines from the Glass Mountains, Texas, and has submitted it for publication. He has also recently submitted for publication a study on population variations in charophyte gyrogonite species from the Morrison formation in the Colorado Front Range. His current research includes restudy of the Leonard and Word formations and their fusuline faunas.

In Cretaceous micropaleontology, one project is nearing publication and another has just begun. Dr. Don Eicher, now teaching at the University of Colorado, has in press as a Peabody Museum Bulletin his paper "Stratigraphy and micropaleontology of the Thermopolis shale." James Mello has begun a study of the micropaleontology of the upper part of the Pierre shale and Fox Hills formations in the Missouri Valley region of South Dakota.

Dr. June R. P. Phillips is engaged in a study of Middle Ordovician bryozoans from the type areas in New York State. Her paper "Restudy of types of seven Ordovician bifoliate bryozoan genera" is in press in "Palaeontology"; manuscripts re-evaluating the type species of *Ptilodictya* and *Arthropora* have been submitted for publication; and a manuscript on the larger cryptostomatous bryozoa in the Ordovician and Silurian of Anticosti Island is being completed.

Rutgers University

The micropaleontology laboratory has a number of important projects in progress. Dr. Richard K. Olsson

is making a study of Cretaceous planktonic foraminifera from the Marshalltown, Mount Laurel, Navesink and Red Bank formations of New Jersey and Delaware. This program is sponsored by the Rutgers Research Council. Dr. Olsson is also working on the benthonic foraminifera from the type Marshalltown. Dr. Steven K. Fox is studying the foraminiferal fauna of the New Jersey Shark River formation (middle Eocene). Two graduate students have theses studies in progress: Alfred Hirsch is working on the microfauna of the type Mancos (Cretaceous) shale of Colorado and Donald Nogan is making a re-examination and re-evaluation of the Aquia (Eocene) foraminifera of Maryland and Virginia.

New York University

The Department of Geology reports that several research problems have been completed, and that substantial progress has been made on a number of other projects. David D. Hughes has completed his Master's thesis on the nummulite succession of the Libyan Paleogene, and Richard Chiappetta has completed a palynological study of two Cretaceous—Tertiary subsurface sections from Ghana. An improved processing methos developed by Harold L. Cousminer, of New York University and Gulf Oil Corporation, facilitated a more conclusive correlation of the Ghanan sections. The new method of recovery increases the yield fourfold with better preservation of the micro floval elements.

Thomas Dimopoullos, now at Louisiana State University, is completing his Master's thesis *in absentia*. His study deals with the subsurface Cretaceous of Long Island. He reports that spores present indicate a Turonian-Coniacian age for cores taken from the Magothy(?) formation. This is in partial agreement with the age assigned to the Magothy formation as exposed in New Jersey; it also appears to be possible to separate the Upper Cretaceous Raritan formation from the Magothy(?) formation on the basis of marked changes in microfloral frequencies.

Edwin K. Hoiles is engaged in a study of random thin sections of smaller index foraminifera, and hopes to complete the project later in the year. Richard A. Grossman's palynological study of New Jersey coastal plain sediments has been temporarily interrupted by six months of military service.

With the exception of the defense of his dissertation on polymorphism in various living foraminiferal populations, Harold L. Cousminer has successfully completed all oral and written requirements for his doctorate. Foster D. Smith expects to complete his doctoral dissertation on the micropaleontology and stratigraphy of the Oficina formation (Oligocene to lower Miocene) of Venezuela in the early part of the year.

The research vessel *Sea Owl* continues to operate as a floating laboratory in a study of sediments and micro-organisms of Long Island Sound. The foraminiferal component of the cores secured on this project has been under study by Richard Charmatz, who expects to complete the study during this collecting season. Frank Giordano has begun a study of the ostracodes recovered from the cores, and Stratton Podaras is working on the microfloral elements of the same samples.

Dr. Shoshiro Hanzawa joined the faculty of the Department of Geology for the 1959 spring semester. He lectured on larger foraminifera. A similar course, dealing with diagnostic characters of larger foraminifera in thin sections was taught by Noel K. Brown, of the Gulf Oil Corporation, during the 1959 fall semester. Dr. Emma Sainz-Amor, of the University of Barcelona, is now studying in the Department on a post-doctoral fellowship.

The reference collection of acid-residue microfossil material from known stratigraphic positions continues to be supplemented.

American Museum of Natural History

The Department of Micropaleontology recently received a grant-in-aid from the National Science Foundation in support of basic research on the biology of the foraminifera. This study is to be supervised by Dr. John Lee, under the direction of Dr. Brooks F. Ellis and Miss Angelina R. Messina. A new laboratory was established in the Department, early in the year to accomodate this research.

Miss Lili E. Ronai, formerly with the Jersey Production Research Company, Tulsa, Oklahoma, has joined the Department as Scientific Assistant. Her duties include the supervision of work in the departmental laboratories.

Miss Caroline A. Turco and Richard Charmatz are now serving as Scientific Assistants in the Department of Micropaleontology. A paper on conodonts of the Eden group (Upper Ordovician) of Ohio and Kentucky, by Sweet, Turco, Warner and Wilke, appeared last fall in the Journal of Paleontology (1959, vol. 33, no. 6).

During 1959, the following micropaleontologists were among the numerous visitors to the Department: Esteban Boltovskoy, Paul Bronniman, W. Storrs Cole, Arthur N. Dusenbury, Jr., William Gwinn, Shoshiro Hanzawa, Clara Hires, David D. Hughes, Doris Low, Eugenia Montanaro-Gallitelli, Frances Parker, Charles Ross, Emma Sainz-Amor, Madame Zoya Stschedrina, Leo Shishkevitch, I. G. Sohn, Benton Stone, Ruth Todd, Alfred Traverse, Eugene Tynan and L. R. Wilson.

Lamont Geological Observatory

William Wiles has completed the initial phase of his study of the pores of the planktonic foraminifera, finding among other things, that the pore concentrations per unit area of the test walls of certain species can be used as Pleistocene climate indicators. Miss Yvonne Herman is now working on the foraminifera in a series of cores from the bottom of the

Red Sea. Allan Bé is studying the distribution of living planktonic foraminifera in the North and South Atlantic, and in particular the seasonal distribution of planktonic species in the Bermuda region and in plankton samples collected at weather stations of Coast Guard vessels. David Ericson is persisting in his attempt to establish a Pleistocene stratigraphical section in deep-sea sediment cores from the Atlantic.

Pennsylvania State University

Robert Sohn is completing work on ostracodes from the Glenerie limestone in New York State. David Nickey is studying some Ordovician ostracodes. Norman Frederiksen is working on the palynology of the Pottsville-Allegheny boundary in the Brookville Basin of western Pennsylvania. Gilbert Brenner is working on the palynology of the Brookville-Clarion coals of western Pennsylvania. H. T. Ames is working on the Catalog of Fossil Pollen and Spores. E. A. Stanley is studying the palynology of the Cretaceous-Tertiary boundary in western South Dakota.

University of North Carolina

The following projects in the last report still in progress are: a paper by Charles W. Copeland on upper Miocene and upper Eocene foraminifera from two localities in Duplin County, North Carolina; a study of the Recent foraminifera from Core Sound, southern Pamlico Sound and the Neuse River estuary, North Carolina, by Marcus B. Morehead; and Middle Devonian stromatoporoids from southern Ontario, by Joseph St. Jean, Jr.

Marcus B. Morehead reported on an Upper Cretaceous foraminiferal fauna from the bluffs of the Nuese River at Kinston, North Carolina. C. Everett Brett reported on a similar Black Creek foraminiferal fauna from the Cape Fear River. Both papers were given before the North Carolina Academy of Sciences meeting last spring and appeared in the November 1959 issue of the Journal of the Elisha Mitchell Scientific Society.

A new project on an Upper Silurian Keyser stromatoporoid fauna from western Virginia is being undertaken by Bobby G. Cahoon. Professor J. J. Frankel, who is visiting the Geology Department from the University of Natal, at Durban, South Africa, found a small foraminiferal fauna from a formation heretofore considered non-fossiliferous which seems to correlate with the Pleistocene Bluff Beds of South Africa. The fauna will be described by St. Jean in a stratigraphic paper being prepared by Frankel.

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